.0c4

PROCEEDINGS 45TH YEAR

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

VOLUME XV

1926

BALTIMORE, MD.
THE WAVERLY PRESS
1926

TABLE OF CONTENTS

SUBJECT INDEX

AUTHOR INDEX AND NAME REFERENCE

INDEX TO ABSTRACTS

I. Authors

INDEX TO ABSTRACTS

II. Subjects

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

Vol. 15 JANUARY, 1926 No. 1

CONTENTS

OFFICERS OF THE
AMERICAN WATER WORKS ASSOCIATION

OFFICERS OF THE AMERICAN WATER WORKS ASSOCIATION (Continued)

Central States Section.—President, J. W. Ellms; Vice-President, Chester F. Drake; Trustees, J. C. Beardsley, D. C. Grobbel, Mentor Hetzer.

4-States Section.—President, Edgar M. Hoopes, Jr.; Vice-presidents, L. Van Gilder, John C. Trautwine, Jr., V. Bernard Siems; Secretary-Treasurer, C. R. Wood; Executive Committee, J. W. Ledoux, M. E. Bartlett, W. H. Boardman, H. D. Brown, George McKay, and the officers.

Illinois Section.—Chairman, L. R. Howson; Vice-Chairman, W. R. Gelston; Secretary, G. C. Habermeyer; Treasurer, H. E. Keeler; Trustees, W. E. Lautz, C. M. Roos, H. M. Ely.

Indiana Section.—Chairman, J. O. Endris; Vice-Chairman, Wm. Luscombe; Secretary-Treasurer, C. K. Calvert; Assistant Secretary-Treasurer, B. J. T. Jeup.

Iowa Section.—Chairman, Max Levine; Vice-Chairman, Homer V. Knouse; Secretary-Treasurer, J. J. Hinman, Jr.; Directors, J. W. McEvoy, N. T. Veatch, Jr.

Kentucky-Tennessee Section.—Chairman, W. S. Cramer; Vice-Chairman, Carl E. Davis; Secretary-Treasurer, F. C. Dugan; Directors, R. E. Lowe, W. S. Patton.

Minnesota Section.—Chairman, C. M. Crowley; Vice-Chairman, J. A. Childs; Secretary-Treasurer, Arthur F. Mellen; Trustees, Chas. Foster, A. D. Horne, E. McCulloh.

Montana Section.—Herbert B. Foote, Acting Chairman.

New York Section.—President, B. B. Hodgman; Secretary, E. D. Case; Board of Governors, E. D. Case, B. B. Hodgman, F. T. Kemble, Thaddeus Merriman.

North Carolina Section.—President, J. O. Craig; Vice-president, M'Kean Maffitt; Secretary-Treasurer, Thorndike Saville; Executive Committee, G. F. Catlett, E. G. McConnell, H. E. Miller, A. O. True, W. E. Vest, and the officers.

Wisconsin Section.—Chairman, W. D. Leonard; Vice-Chairman, Edward Brown; Past Chairman, L. A. Smith; Secretary-Treasurer, C. M. Baker; Director, William Koehn.

// JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

VOL. 15 JANUARY, 1926 No. 1

EFFECT OF WATER RATES AND GROWTH IN POPULATION UPON PER CAPITA CONSUMPTION[1]

BY LEONARD METCALF[2]

Periodically every administrator of an important water works property is confronted with the necessity for reviewing critically the relative capacity and probable future demand for water upon his works. With growths in population of 20 to 30 per cent per decade, normal in this country, experience has shown that radical extensions and betterments are required at periods of twelve to fifteen years. The periods of economic design for different portions of the plant vary, of course, as for instance with the major sources of supply it is generally found advantageous to look forward and build structures for periods in advance of forty to fifty years. With a distribution pipe system which can be reinforced from time to time, a period of anticipation of fifteen to twenty years is more common.

In the case of the sources of supply, particularly in the semi-arid and arid regions and the rapidly growing regions of the East, it becomes of importance to anticipate the needs and purchase the necessary water rights lest their purchase at a later date, with the cost involved in the developments that may have been made or structures that may have been built upon them, be prohibitive.

[1] Presented before the Pennsylvania Water Works Association, October 22, 1925. Reprinted here by permission of the Pennsylvania Water Works Association.

[2] Consulting Engineer, of Metcalf and Eddy, Boston, Mass.

The scope of this paper is limited to certain factors involved in the determination of the future water demand.

It is customary first to make a careful study of the probable future growth in population of the region, which may be accomplished in various ways. In most of our large cities a valuable check upon estimates may be had through the work of the American Telephone and Telegraph Company which makes very careful studies along this line, which will be found helpful in checking independent studies made from the water works point of view.

Next most important is the problem as to what is likely to be the change in rate of water consumption per capita. In this are involved various considerations,—first and most important, the character of the industrial demand; second, the less important commercial demand and the demand of the public service; and finally the demand of domestic service. Unfortunately records of the total amount of water consumed by large industries and the earnings derived therefrom from year to year have not been determined even upon the works more or less fully metered, upon which the data could be assembled. This is much to be regretted. A change in practice is highly desirable. It would almost certainly lead to better administration to have such summations made annually, and with the statistical machinery now available such work can be done at costs well within reasonable limits. If it be not possible to gather such data annually, they should be assembled at least at periods of five years, that they may be coördinated with other factors such as the activity of industry and business.

In default of exact information in regard to total industrial consumption it has been necessary to base the present studies upon the more general information concerning total metered consumption, population and rates.

In looking forward to the future in comparison with the past it is necessary to make estimate of the effect of the increase in population upon daily per capita water demand, and the effect of changes in water rates. There are few, if any, works in which the water rates have remained constant over a long period of years, and the recent war has, of course, materially changed these conditions, resulting in general increases from 35 to 50 per cent in excess of prewar prices, and the tendency in rates is still upwards.

Another means of ascertaining future water demand is found in a forecast of past water consumption, but this too is inadequate and in most cases a more or less uncertain procedure because of the lack of exact knowledge concerning the slip of pumps and the amount of waste and leakage. Moreover in applying this yardstick also, the effect of increase in population and changes in rates must be borne in mind.

The local data if reasonably complete, when finally assembled and fairly treated, should furnish much the best criterion and be of greatest significance in the determination of probable future demand. Nevertheless, it is helpful often to see what the general trend of experience has been, as well as the experience of individual works in communities the character and life history of which are more or less definitely known.

It was with a view to determining such trends that the present work was undertaken. The effort has been made, through assembling the records of 29 different works which have been metered for comparatively long periods of years and are now substantially fully metered, to see if the record might not contain evidence of value. The records assembled have been those most available and covering a wide range of populations and water rates.

In table 1 are shown "Data on consumption, per cent of services metered and water rates for several cities." To this record of 29 cities has been added the record of New York City merely for purposes of comparison, because it was the largest city in the country and might be of interest in the plotting of the results, but inasmuch as but 25 per cent of the water services of the city are metered the record has not been given weight in the analysis of results, which are based essentially upon the records of the 29 cities cited.

These records were obtained by correspondence with the superintendents of the various works and after assembling the table, copy was resubmitted for comment and correction. It is difficult, of course, to make such a compilation which shall be absolutely comparable in every way, but the effort has been made here to get a record which should be as fairly characteristic and significant as possible.

The diagrams have been based upon the population figures shown in table 1, the probable present safe amount of the per capita water consumption in gallons per day; and the statement of rates in the three groups—domestic, intermediate and manufacturing, following

TABLE 1

Data on consumption, per cent of services metered and water rates for various cities

City	Population served 1920	Average daily consumption (M.G.D.) 1924	Per cent of services metered		Per capita water consumption in gallons per day							Average water rate[1] per 1000 gallons — Gallons per month		
			Average 5 years 1920–1924	1924	1920	1921	1922	1923	1924	Average 5 years 1920–1924	Probable present safe amount	25,000 (Domestic)	250,000 (Intermediate)	2,500,000 (Manufacturing)
New York City, N. Y.	5,663,980[3,4]	789.2[3]	26	25	130.0[3]	127.0[3]	128.0[3]	131.0[3]	131.0[3]	129.0[3]	135[3]	$0.13	$0.13	$0.13
Massachusetts Metropolitan District	1,213,430[4]	124.10	82	95	105.0	95.0	94.0	97.0	95.0	97.0	100	0.21[9]	0.19[9]	0.18[9]
Detroit, Mich.	1,061,972	183.97	98	99	143.0	143.0	148.0	135.0	134.0	141.0	140	0.10[10]	0.08[10]	0.06[10]
Cleveland, Ohio	925,283	151.18	98	98	151.7	135.0	137.3	149.6	140.8	142.9	145	0.08	0.08	0.08
Boston, Mass	751,810[4]	87.68	73	94	125.0	112.0	110.0	113.0	111.0	114.0	115	0.21	0.19	0.18
Milwaukee, Wis	500,000	69.02	98	99	133.8	122.2	124.5	132.0	125.4	127.6	130	0.10[10]	0.09[10]	0.09[10]
Cincinnati, Ohio	414,500	48.94	100	100	119.4	114.7	117.0	115.6	115.1	116.4	120	0.16	0.16	0.16
Newark, N. J.	414,216	43.6	94	96	108.2	91.8	95.4	99.8	97.8	98.6	100	0.15[10,11]	0.14[10,11]	0.13[10,11]
Minneapolis, Minn	380,582	42.77	100	100	98.8	100.0	100.0	107.0	102.5	101.7	105	0.08	0.08	0.08
Kansas City, Mo	334,193	48.33	81	83	142.6	132.3	138.3	132.5	125.9	134.3	135	0.22	0.17	0.11
Rochester, N. Y	278,000	26.4	99	99	95.7	96.2	88.8	86.3	85.6	90.5	90	0.18	0.17	0.15
Providence, R. I	270,472	23.62	94	95	80.0	78.5	81.2	86.0	83.0	82.0	85	0.24	0.17	0.11
Toledo, Ohio	243,164	29.0	99	100	104.0	101.0	109.0	106.0	102.0	104.0	110	0.13	0.12	0.11
Columbus, Ohio	240,000	23.20	99	99	94.1	82.3	83.6	88.5	85.9	86.9	90	0.16	0.16	0.15
St. Paul, Minn.	234,698	20.38	96	98	81.2	80.7	81.6	80.1	72.7	79.3	80	0.09[10]	0.09[10]	0.09[10]
Worcester, Mass	179,923	16.27	97	98	92.1	82.5	84.5	85.1	84.5	85.7	90	0.20	0.15	0.10
Hartford, Conn	165,000	16.16	100	100	78.6	76.7	84.1	95.6	88.8	84.8	90	0.16	0.16	0.10
Grand Rapids, Mich.	145,000	15.91	99	99	98.0	94.0	98.0	113.0	99.0	100.0	105	0.09	0.09	0.09
New Bedford, Mass.	131,350	9.71	95	93	78.0	71.0	71.0	77.0	67.0	73.0	75	0.16[10,12]	0.10[10,13]	0.10[10,13]
Springfield, Mass.	130,114[5]	13.52[5]	99	99	96.0[5]	90.0[5]	87.0[5]	91.0[5]	89.0[5]	91.0[5]	95[5]	0.18	0.08	0.07

Fall River, Mass.	124,843	6.79	100	100	51.1	55.3	49.5	54.1	51.9	52.4	55	0.28	0.20	0.14
Lowell, Mass.	112,759	6.54	89	90	63.4	58.0	56.1	54.5	52.3	56.9	60	0.28	0.28	0.28
Yonkers, N. Y.	101,176	13.41[6]	100	100	110.0[6]	105.0[6]	114.0[6]	112.0[6]	122.0[6]	113.0[6]	120[6]	0.21[12]	0.13[13]	0.13[13]
Lawrence, Mass.	94,270	4.64	96	97	49.0	43.0	46.0	46.0	45.0	46.0	50	0.20	0.20	0.20
Brockton, Mass.	80,206	4.19	100	100	43.3	43.6	43.9	47.3	50.0	45.6	50	0.26[10]	0.16[10]	0.14[10]
Manchester, N. H.	80,000	6.35	83	85	67.7	66.5	68.4	76.2	76.6	71.1	75	0.13	0.13	0.10
Woonsocket, R. I.	48,360	3.07[7]	96[8]	96[7]	53.0	50.7	53.8	59.8		54.3[8]	60	0.28	0.14	0.10
Madison, Wis.	38,378	4.77	100	100	102.0	99.0	101.0	106.0	102.0	102.0	105	0.12[10]	0.09[10]	0.06[10]
Waltham, Mass.	31,000	2.23	98	100	63.8	63.2	67.2	65.5	65.5	65.0	70	0.22	0.15	0.15
San Francisco, Cal.[2]	506,676	39.31	100	100	71.4	70.3	63.7	62.2	58.2	65.2	65	0.40[10]	0.33[10]	0.30[10]

[1] Rates averaged to nearest cent only.
[2] Private company.
[3] Includes supply from both municipal and private works.
[4] Population for July 1, 1920.
[5] Data given on basis of population of "Springfield District" only.
[6] Consumption in Yonkers high on account of sugar refineries and other manufacturing plants.
[7] For 1923.
[8] Average for four years 1920–1923.
[9] Weighted average.
[10] Includes service charge. Assumed size of meter for stated quantities: Domestic ⅝ inch; intermediate 2 inches, manufacturing, 6 inches.
[11] Rates for high pressure service are one-third higher.
[12] Rate for purposes other than manufacturing.
[13] Rate for manufacturing purposes.

this standard classification of quantities of the New England Water Works Association.

	GALLONS PER MONTH	EQUIVALENT GALLONS PER		
		Day	Quarter	Year
Domestic service	25,000	830	75,000	300,000
Intermediate service	250,000	8,300	750,000	3,000,000
Manufacturing service	2,500,000	83,000	7,500,000	30,000,000

In determining the relative water rates, allowance has been made for the "service charge" in those cities making use of it, the service charge being based upon a $\frac{3}{4}$ inch meter for the domestic service; 2-inch meter for the intermediate service and 6-inch meter for the manufacturing service.

The data contained in table 1 were then plotted on different forms of cross-section paper in studying trends, using both natural and logarithmic scales. As an aid to judgment there were also prepared figures 1 and 2, showing the increase in per capita consumption with growth in population for different cities, utilizing the available record extending in many cases over long periods of years and noting upon these diagrams the gradual increase in per cent of services metered. These lines were of material assistance in determining trends. The trend line shown upon the two diagrams was taken from figure 3.

In figure 3 are shown the "Apparent trends in relation of per capita water consumption to population, for cities with different water rates," the record of each city being plotted with the name of the city beside it and the prevailing water rate per thousand gallons, for manufacturing service for assumed quantities of 2,500,000 gallons per month. Three lines showing trends were finally drawn, correlating the entire evidence, the heavy line in the center corresponding to water rates of from 10 to 13 cents per thousand gallons for manufacturing quantities (2.5 million gallons per month) and dotted lines covering rates below 10 cent per thousand gallons and rates above 13 cents per thousand gallons.

In figure 4 are shown the "Apparent trends in relation of per capita consumption to water rates," in three groups covering domestic rates, intermediate rates and manufacturing rates as heretofore defined, the name of the city being shown before each record; and in figure 5 are assembled the combined results shown in figure 4 in

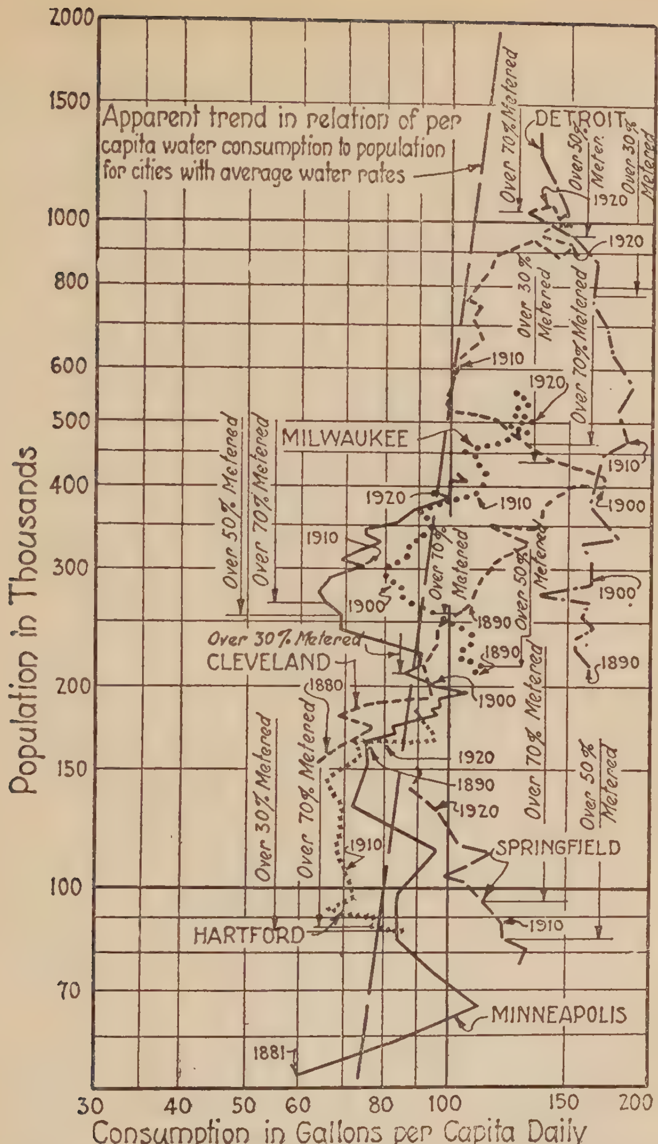


Fig. 1. Increase in Per Capita Consumption with Growth in Population for Different Cities

Note: The existing water rates (manufacturing) for the cities plotted are as follows:

	cents per 1000 gallons		cents per 1000 gallons
Detroit	6	Minneapolis	8
Cleveland	8	Hartford	10
Milwaukee	9	Springfield	7

These rates are average rates for an assumed quantity of 2,500,000 gallons per month.

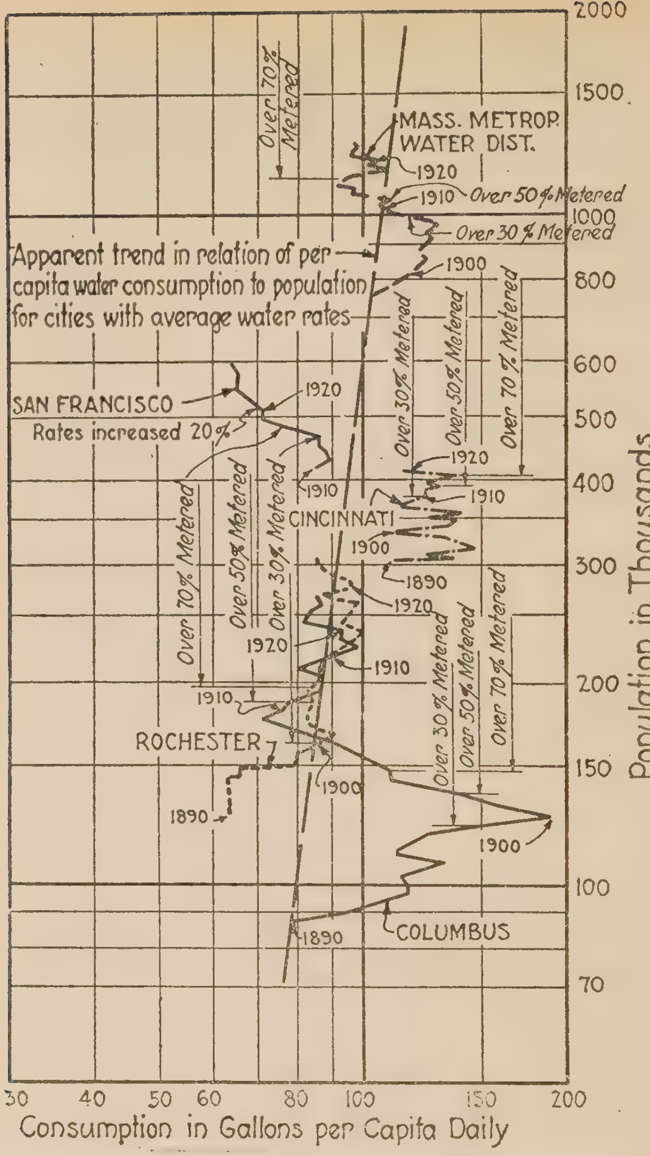


FIG. 2. INCREASE IN PER CAPITA CONSUMPTION WITH GROWTH IN POPULATION FOR DIFFERENT CITIES

Note: The existing water rates (manufacturing) for the cities plotted are as follows:

	cents per 1000 gallons		cents per 1000 gallons
Massachusetts Metropolitan Water District	18	Columbus	15
Cincinnati	16	Rochester	15
		San Francisco	30

These rates are average rates for an assumed quantity of 2,500,000 gallons per month.

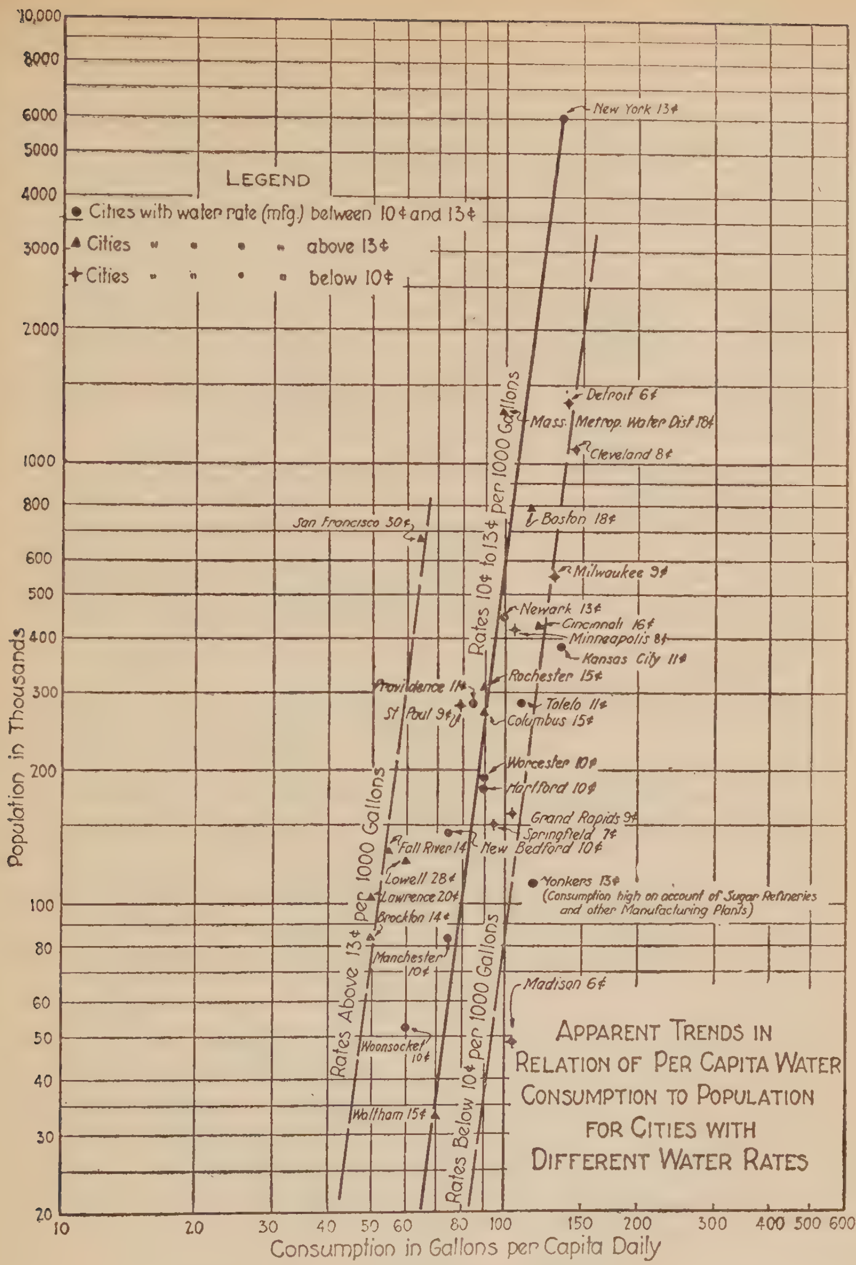


FIG. 3

The prices shown for the cities plotted indicate the average rates per 1000 gallons for an assumed quantity of 2,500,000 gallons per month for manufacturing pruposes.

Populations are as estimated for 1924.

Per capita water consumptions are probable present safe amounts, estimated from records of 1920 to 1924 inclusive.

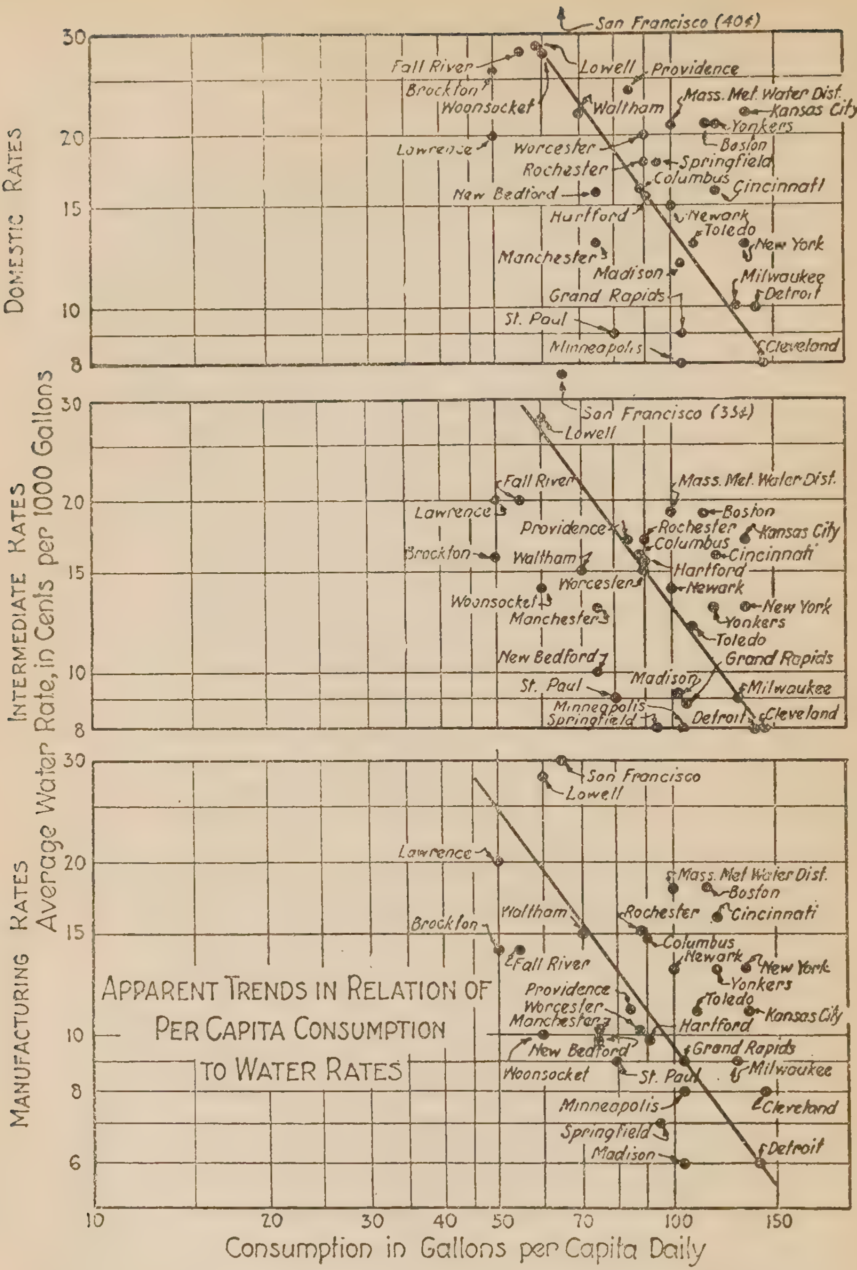


FIG. 4

The per capita consumption for the cities shown are probable present safe amounts estimated from records of 1920 to 1924 inclusive.

The water rates are the average rates for assumed quantities of 25,000 gallons per month for domestic rates; and 250,000 gallons per month for intermediate rates and 2,500,000 gallons per month for manufacturing rates.

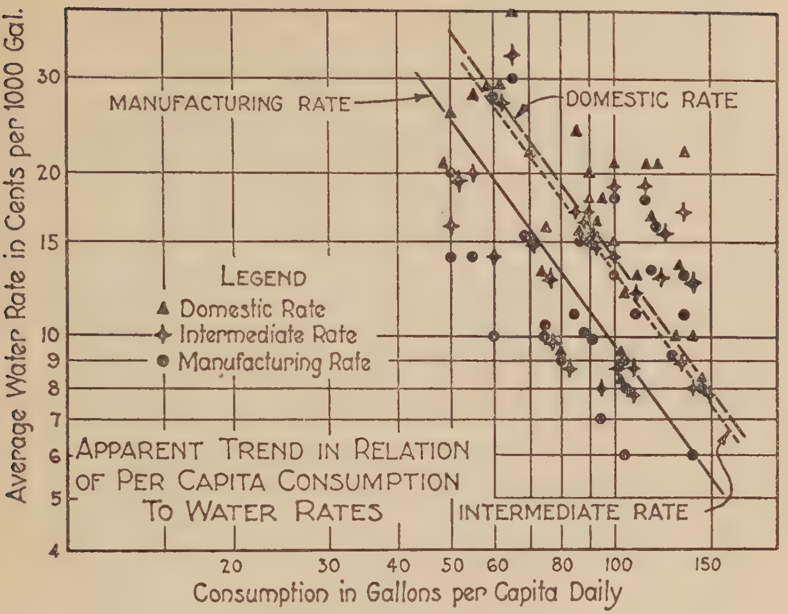


FIG. 5

The points plotted represent the rates of per capita consumption for 30 different cities, plotted in each case for the domestic, intermediate and manufacturing rates of the city.

The per capita consumption are probable present safe amounts, estimated from records of 1920 to 1924 inclusive.

The domestic, intermediate and manufacturing rates are the average rates for assumed quantities of 25,000 gallons, 250,000 gallons and 2,500,000 gallons per month, respectively.

TABLE 2

Effect of growth in population on water consumption for various cities

Group	No.	City	Period of years: Years taken	Period of years: Length of period	Per cent of services metered: Beginning	Per cent of services metered: End	Population: Beginning	Population: End	Population: Annual increase in per cent (compounded annually)	Total consumption (M.G.D.): Beginning	Total consumption (M.G.D.): End	Total consumption (M.G.D.): Annual increase in per cent (compounded annually)	Per capita consumption (gallons per day): Beginning	Per capita consumption (gallons per day): End	Per capita consumption (gallons per day): Annual increase in per cent (compounded annually)	Meter rates: Minimum charge: Monthly	Meter rates: Minimum charge: Annual	Meter rates: Domestic rate per 1000 gallons	Meter rates: Intermediate rate per 1000 gallons	Meter rates: Manufacturing rate per 1000 gallons
Group 1 (present population over 1,000,000)	1	Detroit, Mich.	1920–1924	4	97	99	1,066,000	1,372,000	6.6	152.0	184.0	4.9	143	134	−1.5	$0.42	$5.00	$0.10	$0.08	$0.06
	2	Massachusetts Metropolitan district	1913–1924	11	58	95	1,110,000	1,300,000	1.4	103.8	124.1	1.7	94	95	0.1	0.67	8.00	0.21	0.19	0.18
	3	Cleveland, O.	1908–1924	16	94	98	519,000	1,074,000	4.7	52.1	151.2	6.9	100	141	2.2	0.50	6.00	0.08	0.08	0.08
		Straight average for Group 1..........		10	83	97	898,000	1,249,000	4.2	102.6	153.1	4.5	112	123	0.3	0.53	6.33	0.13	0.12	0.11
Group 2 (present population between 250,000 and 1,000,000)	4	Boston, Mass.	1913–1924	11	41	94	733,000	788,000	0.6	79.4	87.7	0.9	108	111	0.3	0.67	8.00	0.21	0.19	0.18
	5	San Francisco, Cal.	1919–1924	5	100	100	565,000	610,000	1.6	35.7	39.3	1.9	63	64	0.4	0.78	9.36	0.40	0.33	0.30
	6	Milwaukee, Wis.	1901–1924	23	89	99	300,000	550,000	2.7	24.0	69.0	4.7	80	125	2.0	0.17	2.00	0.10	0.09	0.09
	7	Newark, N. J.	1917–1924	7	88	96	418,000	446,000	1.0	45.6	43.6	−0.6	109	98	−1.5	0.50	6.00	0.15	0.14	0.13
	8	Cincinnati, O.	1914–1924	10	61	100	397,000	425,000	0.7	50.8	48.9	−0.4	128	115	−1.1	0.40	4.80	0.16	0.16	0.16
	9	Minneapolis, Minn.	1908–1924	16	76	100	277,000	417,000	2.6	17.8	42.8	5.6	64	102	2.9	0.33	4.00	0.08	0.08	0.08
	10	New Orleans, La.	1918–1924	6	100	100	389,000	412,000	1.0	33.2	45.4	5.4	85	110	4.3	0.25	3.00	0.11	0.09	0.07
	11	Kansas City, Mo.	1916–1924	8	70	83	315,000	384,000	2.5	32.7	48.3	5.0	104	126	2.4	0.70	8.40	0.22	0.17	0.11
	12	Rochester, N. Y.	1908–1924	16	87	99	202,000	309,000	2.7	17.6	26.4	2.6	87	86	−0.1	0.50	6.00	0.18	0.17	0.15
	13	Providence, R. I.	1902–1924	22	84	95	198,000	284,000	1.6	11.6	23.6	3.3	58	83	1.6	0.67	8.00	0.24	0.17	0.11
	14	Toledo, O.	1910–1924	14	85	100	168,000	283,000	3.8	15.6	29.0	4.5	93	102	0.7	0.71	8.50	0.13	0.12	0.11
	15	St. Paul, Minn.	1914–1924	10	85	99	225,000	280,000	2.2	13.5	20.4	4.2	60	73	2.0	0.30	3.60	0.09	0.09	0.09
	16	Columbus, O.	1910–1924	14	91	99	182,000	270,000	2.8	13.8	23.2	3.8	76	86	0.9	0.40	4.80	0.16	0.16	0.15
		Straight average for Group 2		12	81	97	338,000	420,000	2.0	30.1	42.1	3.1	86	99	1.1	0.40	5.88	0.17	0.15	0.13

	17	San Antonio, Tex.	1913–1924	11	27	60	120,000	210,000	5.2	12.6	23.0	5.7	105	109	0.4	0.80	9.60			
	18	Worcester, Mass.	1896–1924	28	93	98	103,000	192,000	2.2	6.1	16.3	3.6	60	84	1.3	0.33	4.00	0.20	0.15	0.10
	19	Hartford, Conn.	1905–1924	19	99	100	91,000	182,000	3.7	6.2	16.2	5.2	69	89	1.3			0.16	0.16	0.10
	20	Dayton, O.	1917–1924	7	81	87	141,000	170,000	2.8	12.7	16.7	3.9	90	98	1.2	0.55	6.60	0.13	0.09	0.07
Group 3 (present population between 100,000 and 250,000)	21	Grand Rapids, Mich.	1915–1924	9	75	100	125,000	160,000	2.8	10.5	15.9	4.8	84	99	1.9	0.67	8.00	0.09	0.09	0.09
	22	Springfield, Mass.	1913–1924	11	94	99	99,000	151,000	3.9	10.7	13.5	2.1	108	89	−1.8	0.67	8.00	0.18	0.08	0.07
	23	New Bedford, Mass.	1914–1924	10	96	93	108,000	145,000	3.0	7.4	9.7	2.7	69	67	−0.3	0.42	5.00	0.16	0.10	0.10
	24	Fall River, Mass.	1900–1924	24	94	100	108,000	131,000	0.9	3.8	6.8	2.5	35	52	1.7			0.28	0.20	0.14
	25	Lowell, Mass.	1909–1924	15	77	90	105,000	125,000	1.2	5.2	6.5	1.5	50	52	0.3			0.28	0.28	0.28
	26	Yonkers, N. Y.	1909–1924	15	100	100	76,000	110,000	2.5	7.6	13.4	3.8	100	122	1.3	0.67	8.00	0.21	0.13	0.13
	27	Lawrence, Mass.	1905–1924	19	88	97	69,000	103,000	2.1	3.0	4.6	2.3	43	45	0.3	0.58	7.00	0.20	0.20	0.20
	28	Somerville, Mass.	1913–1924	11	61	94	83,000	101,000	1.8	6.0	7.8	2.4	72	77	0.6	0.50	6.00	0.16	0.16	0.12
		Straight average for Group 3..........		15	82	93	102,000	148,000	2.7	7.6	12.5	3.4	74	82	0.7	0.58	6.91	0.19	0.15	0.13
	29	Brockton, Mass.	1911–1924	13	100	100	69,000	84,000	1.5	2.7	4.2	3.5	39	50	1.9			0.26	0.16	0.14
	30	Manchester, N. H.	1904–1924	20	70	85	62,000	83,000	1.5	3.1	6.4	3.7	50	77	2.2	0.67	8.00	0.13	0.13	0.10
	31	Malden, Mass.	1913–1924	11	99	99	48,000	53,000	0.9	2.23	2.86	2.3	46	54	1.4	0.58	7.00	0.21	0.20	0.19
	32	Quincy, Mass.	1913–1924	11	86	91	36,000	53,000	3.6	2.7	4.4	4.5	76	82	0.7	1.17	14.00	0.31	0.24	0.19
Group 4 (present population between 25,000 and 100,000)	33	Woonsocket, R. I.	1893–1923	30	86	96	23,000	51,000	2.7	0.6	3.1	5.6	24	60	3.1	0.83	10.00	0.28	0.14	0.10
	34	Madison, Wis.	1897–1924	27	89	100	18,000	48,000	3.7	0.8	4.8	6.9	44	102	3.2			0.12	0.09	0.06
	35	Chelsea, Mass.	1913–1924	11	98	100	36,000	47,000	2.5	2.88	3.55	1.9	80	76	−0.5	0.50	6.00	0.15	0.15	0.15
	36	Medford, Mass.	1913–1924	11	100	100	26,000	46,000	5.3	1.2	2.4	6.5	48	53	0.9	0.50	6.00	0.20	0.16	0.16
	37	Everett, Mass.	1913–1924	11	40	89	37,000	44,000	1.6	2.4	4.5	5.9	65	102	4.2	0.50	6.00	0.16	0.15	0.12
	38	Taunton, Mass.	1905–1923	18	46	88	28,000	37,000	1.6	1.9	3.6	3.6	69	99	2.0	0.75	9.00	0.25	0.18	0.11
	39	Waltham, Mass.	1919–1924	5	91	100	31,000	33,000	1.2	1.9	2.2	3.0	61	66	1.6	0.83	10.00	0.22	0.15	0.15
	40	Revere, Mass.	1913–1924	11	50	87	21,000	31,000	3.6	1.39	2.29	4.7	67	74	0.9	0.83	10.00	0.19	0.15	0.15
	41	Watertown, Mass.	1913–1924	11	100	100	14,000	26,000	5.8	0.87	1.66	6.1	62	63	0.2	0.83	10 00	0.33	0.30	0.22
		Straight average for Group 4..........		15	81	95	35,000	49,000	2.7	1.9	3.5	4.5	56	74	1.7	0.73	8.73	0.22	0.17	0.14

TABLE 2—*Continued*

		CITY	PERIOD OF YEARS		PER CENT OF SERVICES METERED		POPULATION			TOTAL CONSUMPTION (M.G.D.)			PER CAPITA CONSUMPTION (GALLONS PER DAY)			METER RATES				
			Years taken	Length of period	Beginning	End	Beginning	End	Annual increase in per cent (compounded annually)	Beginning	End	Annual increase in per cent (compounded annually)	Beginning	End	Annual increase in per cent (compounded annually)	Minimum charge: Monthly	Minimum charge: Annual	Domestic rate per 1000 gallons	Intermediate rate per 1000 gallons	Manufacturing rate per 1000 gallons
Group 5 (present population below 25,000)	42	Arlington, Mass.	1913–1924	11	100	100	13,000	24,000	5.8	0.79	1.40	5.3	63	59	−0.5	1.25	15.00	0.20	0.16	0.14
	43	Melrose, Mass.	1913–1924	11	100	100	17,000	19,000	1.0	1.14	1.25	0.9	68	64	−0.5	0.75	9 00	0.22	0.20	0.20
	44	Winthrop, Mass.	1913–1924	11	100	100	11,000	18,000	4.6	0.69	0.97	3.2	60	55	−0.7	1.00	12.00	0.24	0.24	0.24
	45	Milford, Mass.	1910–1924	14	57	89	15,000	16,000	0.5	0.8	0.9	0.9	51	56	0.7	1.00	12.00	0.53	0.25	0.21
	46	Belmont, Mass.	1913–1924	11	100	100	6,300	14,000	7.5	0.46	0.89	6.2	73	64	−1.2	0.83	10.00	0.24	0.20	0.20
	47	Milton, Mass.	1913–1924	11	100	100	8,500	11,000	2.3	0.33	0.54	4.6	39	47	1.7	1.00	12.00	0.33	0.33	0.33
	48	Swampscott, Mass.	1913–1924	11	100	100	6,600	8,400	2.2	0.42	0.73	5.2	63	87	3.0	0.92	11.00	0.40	0.40	0.40
	49	Stoneham, Mass.	1913–1924	11	87	100	7,800	8,200	0.5	0.41	0.60	3.5	53	73	3.0	0.83	10.00	0.43	0.32	0.26
	50	Lexington, Mass.	1913–1924	11	79	100	5,400	7,000	2.4	0.36	0.45	2.1	67	64	−0.4	1.00	12.00	0.30	0.22	0.20
	51	Nahant, Mass.	1913–1924	11	60	94	1,400	1,600	1.2	0.17	0.20	1.5	123	126	0.2	0.83	10.00	0.25	0.25	0.25
		Straight average for Group 5..........		11	88	98	9,200	13,000	2.8	0.56	0.79	3.3	66	70	0.5	0.94	11.30	0.31	0.26	0.24

Group 6. (Massachusetts Metropolitan Water District)	4	Boston, Mass.	1913–1924	11	41	94	733,000	788,000	0.6	79.4	87.7	0.9	108	111	0.3	0.67	8.00	0.21	0.19	0.18
	28	Somerville, Mass.	1913–1924	11	61	94	83,000	101,000	1.8	6.0	7.8	2.4	72	77	0.6	0.50	6.00	0.16	0.16	0.12
	31	Malden, Mass.	1913–1924	11	99	99	48,000	53,000	0.9	2.23	2.86	2.3	46	54	1.4	0.58	7.00	0.21	0.20	0.19
	32	Quincy, Mass.	1913–1924	11	86	91	36,000	53,000	3.6	2.7	4.4	4.5	76	82	0.7	1.17	14.00	0.31	0.24	0.19
	35	Chelsea, Mass.	1913–1924	11	98	100	36,000	47,000	2.5	2.88	3.55	1.9	80	76	−0.5	0.50	6.00	0.15	0.15	0.15
	36	Medford, Mass.	1913–1924	11	100	100	26,000	46,000	5.3	1.2	2.4	6.5	48	53	0.9	0.50	6.00	0.20	0.16	0.16
	37	Everett, Mass.	1913–1924	11	40	89	37,000	44,000	1.6	2.4	4.5	5.9	65	102	4.2	0.50	6.00	0.16	0.15	0.12
	40	Revere, Mass.	1913–1924	11	50	87	21,000	31,000	3.6	1.39	2.29	4.7	67	74	0.9	0.83	10.00	0.19	0.15	0.15
	41	Watertown, Mass.	1913–1924	11	100	100	14,000	26,000	5.8	0.87	1.66	6.1	62	63	0.2	0.83	10.00	0.33	0.30	0.22
	42	Arlington, Mass.	1913–1924	11	100	100	13,000	24,000	5.8	0.79	1.40	5.3	63	59	−0.5	1.25	15.00	0.20	0.16	0.14
	43	Melrose, Mass.	1913–1924	11	100	100	17,000	19,000	1.0	1.14	1.25	0.9	68	64	−0.5	0.75	9.00	0.22	0.20	0.20
	44	Winthrop, Mass.	1913–1924	11	100	100	11,000	18,000	4.6	0.69	0.97	3.2	60	55	−0.7	1.00	12.00	0.24	0.24	0.24
	46	Belmont, Mass.	1913–1924	11	100	100	6,300	14,000	7.5	0.46	0.89	6.2	73	64	−1.2	0.83	10.00	0.24	0.20	0.20
	47	Milton, Mass.	1913–1924	11	100	100	8,500	11,000	2.3	0.33	0.54	4.6	39	47	1.7	1.00	12.00	0.33	0.33	0.33
	48	Swampscott, Mass.	1913–1924	11	100	100	6,600	8,400	2.2	0.42	0.73	5.2	63	87	3.0	0.92	11.00	0.40	0.40	0.40
	49	Stoneham, Mass.	1913–1924	11	87	100	7,800	8,200	0.5	0.41	0.60	3.5	53	73	3.0	0.83	10.00	0.43	0.32	0.26
	50	Lexington, Mass.	1913–1924	11	79	100	5,400	7,000	2.4	0.36	0.45	2.1	67	64	−0.4	1.00	12.00	0.30	0.22	0.20
	51	Nahant, Mass.	1913–1924	11	60	94	1,400	1,600	1.2	0.17	0.20	1.5	123	120	0.2	0.83	10.00	0.25	0.25	0.25
		Straight average for Group 6..........		11	83	97	62,000	72,000	3.0	5.8	6.9	3.8	69	74	0.7	0.81	9.67	0.25	0.22	0.21
		Massachusetts Metropolitan district	1913–1924	11	58	95	1,110,000	1,300,000	1.4	103.8	124.1	1.7	94	95	0.1			0.21	0.19	0.18
Group 7 (cities with small per cent of metering)	52	New York City, N. Y.	1920–1924	4	27	25	5,664,000	6,015,000	1.5	734.9	789.2	1.7	130	131	0.2			0.13	0.13	0.13
	53	St. Louis, Mo.	1912–1924	12	7	8	711,000	811,000	1.1	83.5	113.1	2.6	120	140	1.3	0.17	2.00	0.17	0.10	0.07
	54	Indianapolis, Ind.	1910–1924	14	11	23	237,000	362,000	3.1	19.3	32.4	3.8	81	90	0.8	1.40	16.80	0.19	0.16	0.09
		Straight average for Group 7..........		10	15	19	2,204,000	2,396,000	1.9	279.2	311.6	2.7	110	120	0.8	0.78	9.40	0.16	0.13	0.10

detail, for each of the three groups (domestic, intermediate and manufacturing rates).

In this diagram, figure 5, are shown all of the records plotted in the previous figure, and the three trend lines.

In table 5 have been assembled, for purposes of comparison, the average per capita water consumption for cities of different sizes,

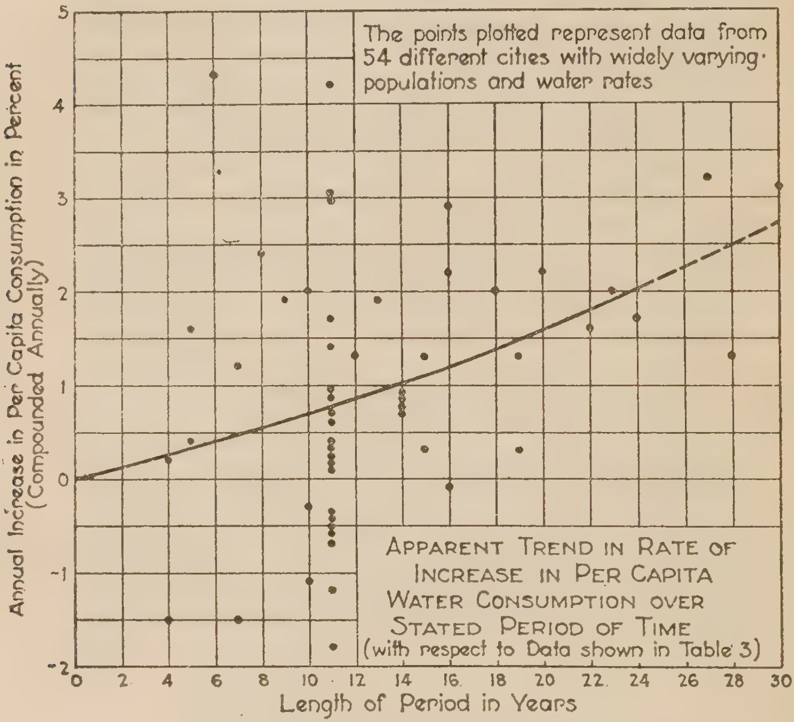


Fig. 6

grouped according to water rates. This table summarizes the trends shown in figure 3.

The conclusions drawn from these several tables and figures will be stated further on after submitting another table (table 2) showing an independent analysis of evidence which has been prepared from reports and other materials available to the author, which is of interest as showing individual characteristics in different cities, but with respect to which the conditions vary to such an extent as to make it impossible to include all of them in the original data submitted in table 1.

In table 2 are shown the further data referred to, upon the effect of growth in population on water consumption for various cities. There are given the name of the city, the period of years of record, the comparisons in per capita consumption being based upon the difference in record for the beginning and the end of said period of years; the per cent of services metered, both at the beginning and the end of the period; the population at the beginning and end of the period, and

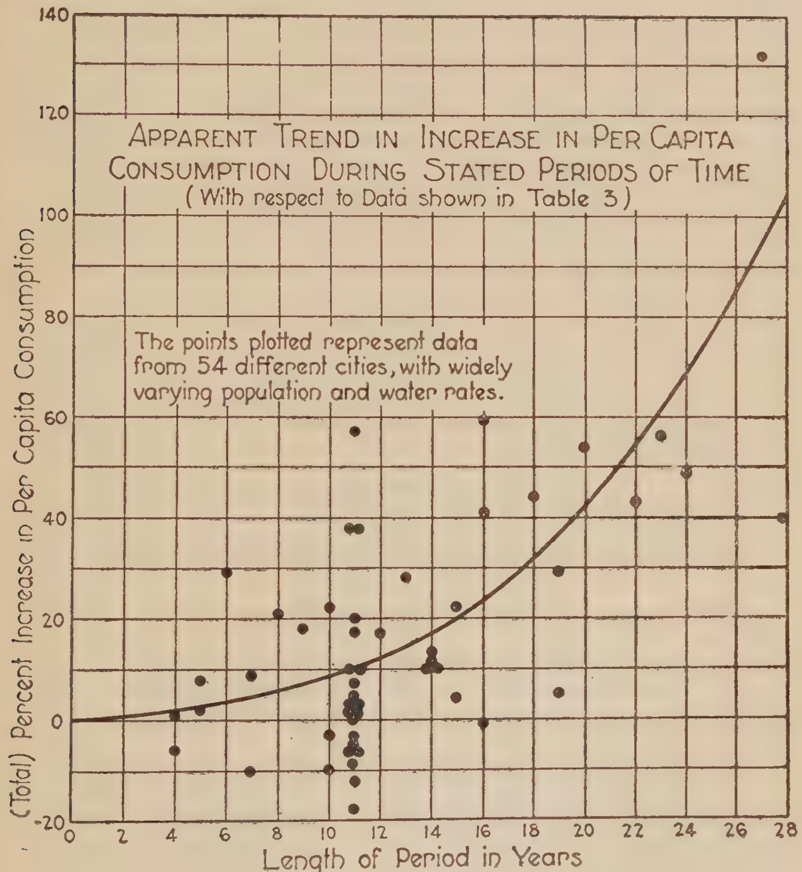


Fig. 7

the equivalent annual rate of increase in per cent, compounded annually, over the period of years stated; the total water consumption in million gallons daily, at the beginning and end of the period, with the resulting annual per cent of increase (compounded annually); the per capita water consumption in gallons per day at the beginning and end of the period; and the annual percentage of increase or decrease compounded annually; and finally the meter rates prevail-

ing in the year 1924 in the cities cited—the minimum charge in monthly and annual terms, and the rates per thousand gallons for domestic, intermediate and manufacturing service as heretofore defined (domestic consumption 25,000 gallons per month, intermediate 250,000 gallons per month, manufacturing 2,500,000 gallons per month). The latter statement of rates is merely for comparative purposes, to give indication of the general amount and variation in the rates.

The record is divided into seven groups and the first five groups have been arranged according to magnitude of population; the sixth group covers the details of the Massachusetts Metropolitan Water District surrounding Boston; the seventh group covers the record of three cities the water service of which is not metered to any large extent—New York City, St. Louis and Indianapolis—for comparative purposes only, all of the other cities being, broadly speaking, nearly fully metered, having in general upwards of 80 per cent of the services metered.

In figure 6 is shown the apparent trend in rate of increase in per capita water consumption over stated periods of time, determined from the data relating to the 54 different cities, contained in table 2. The material variation in individual cases, as well as the general trend, is clearly indicated.

In figure 7 is shown the apparent trend in increase in per capita water consumption during stated periods of time. Here, too, the variation in individual cities as well as the general trend is clearly shown.

CONCLUSIONS

The following conclusions are drawn tentatively. They are to be used only as an aid to judgment and as an additional criterion indicating apparent trends. Adequate local data, carefully analyzed are, of course, likely to prove more significant.

1. Annual or periodical data assembled at five-year intervals are badly needed, concerning the gross and per capita annual water consumption and the gross and per capita revenue derived from industrial service, commercial service, public service and domestic service.

It will probably prove advantageous to adopt the New England Water Works Association scale or some similar scale, to simplify comparison, but if, as some operators and engineers have thought, the difference in metered water scales in different parts of the country

should appear prohibitive, the comparison can still be made within the four groups first stated, the two big important groups being, of course, the large industrial service which varies with the condition of business, and the domestic service which is relatively stable—the commercial service and the public water service being relatively small and constant in amount.

2. The average increase in per capita daily water consumption with increase in population, appears to be about 10 per cent of the increase in population, as indicated in table 3.

TABLE 3

Variations in per capita water consumption corresponding to given variations in populations from data for 30 representative cities shown in table 1 and figure 3

INCREASE IN POPULATION	INCREASE IN PER CAPITA WATER CONSUMPTION
per cent	*per cent*
20	2
40	4
60	6
80	8
100	9

TABLE 4

Variations in per capita consumption corresponding to given variations in water rates, from data from 30 representative cities, shown in table 1 and figures 4 and 5

INCREASE IN RATES	DECREASE IN CONSUMPTION
per cent	*per cent*
20	13
40	22
60	29
80	35
100	40

3. The average decrease in per capita consumption of water, with increase in rates, is indicated by the figures in table 4.

4. With water rates for large industrial services of from 10 to 13 cents per thousand gallons, the average per capita water consumptions appear to increase from 67 g.p.d. for populations of 25,000 to 73 g.p.d. for 50,000, 77 g.p.d. for 75,000, 80 g.p.d. for 100,000, 90

g.p.d. for 250,000, 98 g.p.d. for 500,000, and 107 g.p.d. for 1,000,000 population.

The relative per capita consumptions increase with decrease in water rate and vice versa, as indicated by table 5, thus for industrial water rates of less than 10 cents per thousand gallons, the per capita consumption varies from 86 g.p.d. for a population of 25,000 to 103 for a population of 100,000 and 138 for a population of 1,000,000. Similarly the per capita consumptions for rates greater than 13 cents per thousand gallons decrease to 43, 52 and 70 g.p.d., all of which figures are comparable with those stated above as applying to industrial water service rates of 10 to 13 cents per thousand gallons, as shown in table 5.

TABLE 5

Average per capita water consumption for cities of different sizes, grouped according to water rates*

POPULATION OF CITY	PER CAPITA WATER CONSUMPTION (IN GALLONS PER DAY) For cities with water rate (Manufacturing)		
	Below 10 cents per 1000 gallons	10 to 13 cents per 1000 gallons	Above 13 cents per 1000 gallons
25,000	86	67	43
50,000	94	73	48
75,000	99	77	50
100,000	103	80	52
250,000	116	90	59
500,000	126	98	64
750,000	132	103	67
1,000,000	138	107	70
2,000,000	150	117	76

* As indicated by curves drawn for 30 representative cities.

5. In table 2 the records of variation in annual rate of increase in per capita water consumption are shown for 54 cities, based upon variable periods of record. The latter records, which are believed to be not quite so comparable or significant as those already referred to, indicate the increases over stated period of years in population, total water consumption, and per capita daily water consumption—all given in amount and in per cent compounded annually. The annual increase in per capita consumption, in per cent compounded annually, and the total amount of such increase, over stated periods of time, are shown in figures 6 and 7, respectively.

Figure 6 appears to indicate an average annual rate of increase-in-per cent in per capita water consumption for the 54 cities cited, of 0.75 per cent per decade; that is, that the rate of increase for the first ten years averages 0.75 per cent; for the twenty-year period, 1.5 per cent; and for the thirty-year period 2.75 per cent.

RECORDING THE HYDROGEN ION CONCENTRATION OF POTABLE WATER

By Henry C. Parker[1] and John R. Baylis[2]

INTRODUCTION

Wolman and annan[3] were the first to call attention to the value of hydrogen ion concentration in water treatment. Since the appearance of their article the influence of hydrogen ion concentration on the chemical reactions involved in the treatment of public water supplies has been well established, and no water purification plant using a coagulant before filtration can be operated at its greatest efficiency without a fairly good knowledge of such influence. When a chemical compound, such as aluminum sulfate or lime, is added to the water there is always produced a change in the hydrogen ion concentration. In certain cases the measurement of this change will actually indicate the amount of chemical applied.

The application of lime is generally made for the direct purpose of causing a change in hydrogen ion concentration or pH. Thus, in the "iron and lime" method, the purpose of the lime is to bring the water to approximately that pH at which maximum precipitation of iron hydroxide will take place. In those cases where lime is added for softening purposes, or to prevent corrosion, the purpose is the same—namely, to alter the hydrogen ion concentration. In the application of alum, however, the change in pH is usually incidental and may or may not be in such direction as to aid in the clarification.

It is quite generally recognized that, with alum, the isoelectric point and the maximum precipitation and clarification occur at a pH of between 5.5 and 6.0.[4] Several workers,[5] however, have found that,

[1] Research Department, Leeds & Northrup Co., Philadelphia, Pa.

[2] Principal Sanitary Chemist, Water Department, Baltimore, Md.

[3] Wolman and Hannan, *Chemical & Metallurgical Engineering*, 24, April 17, 1921.

[4] Baylis, *J. Am. Water Works Assoc.*, 10, 373 (1923).

Theriault and Clark, *Pub. Health Reports*, Reprint No. 813.

[5] Norcom, *J. Am. Water Works Assoc.*, 11, 96 (1924).

Catlett, *J. Am. Water Works Assoc.*, 11, 887 (1924).

Hatfield, *J. Am. Water Works Assoc.*, 11, 554 (1924).

for certain waters, optimum conditions exist at pH values below and above these. The optimum condition for certain colored waters has been reported as low as a pH of 4.0, and for certain highly alkaline waters as high as 7.0. It has been found, however, that the majority of our natural waters have an optimum pH value between 5.5 and 6.5. The lower the amount of dissolved salts in the water and the less alum used in the precipitation, the more narrow becomes the favorable zone of precipitation and hence the more important the control of pH. It is evident, therefore, that, if the addition of alum caused the pH to fall sufficiently below 5.5, best results would be obtained by the addition of lime or other alkali to control the final value to a pH of 5.5–6. Conversely, it has been shown[4] that in certain cases economical results may be obtained by the use of acid with the alum to bring the water to the desired pH. The total alum required for clarification is usually determined by the color or turbidity.[6] That the alum usually required for clarification frequently changes the hydrogen concentration in the proper direction, and to such an extent that the zone of maximum clarification is roughly approached, is due more to favorable circumstances than to scientific management. In many water purification plants the alum dosage is undoubtedly used, partially to control the pH and partially for clarification, without any definite conception of the independent effect of the two factors. Using alum to control the pH may not be economical.

In case the optimum condition for alum clarification is secured, which leaves the effluent at a pH of 5.5–6.5, it is evident that further treatment is essential for the prevention of corrosion. It is apparently true that the "harder" waters cause less corrosion at these pH values and consequently it is possible to avoid complaints of "red water" even though no additional treatment is used. However, when the public learns that a properly treated water means a more palatable water, and that considerable savings would be effected in the cost of service pipes and, what is closer to the average household, in soap[7] the water works officials will necessarily have to give more consideration to such treatment.

Hydrogen ion measurements are thus essential, in a water purification plant, both for proper control of the factors affecting precipita-

[6] Pirnie, *J. Am. Water Works Assoc.*, **9**, 247 (1922).

[7] Barr, *J. Am. Water Works Assoc.*, **9**, 295 (1922).

tion and to supply a final product possessing the most favorable characteristics. It is evident that a record of hydrogen ion concentrations would therefore prove of undoubted value.

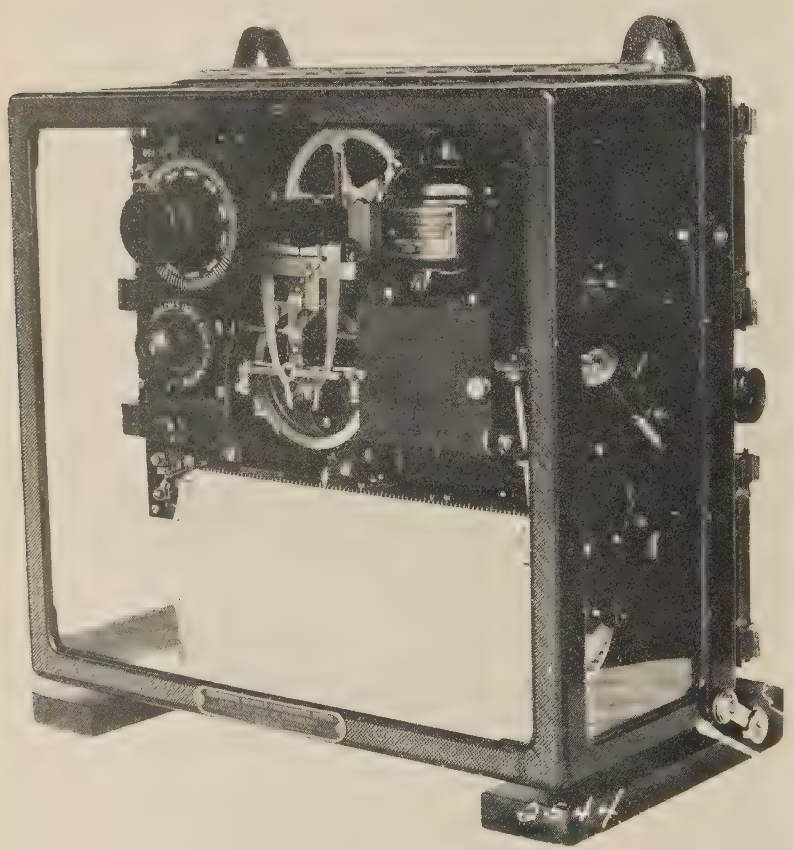


FIG. 1. RECORDING POTENTIOMETER

THE DEVELOPMENT OF SUITABLE ELECTRODES

The recording potentiometer shown in figure 1 has been developed for a number of years and has been employed in a large number of commercial applications. A greatly varied line of indicating and controlling instruments has also been available. To obtain a successful hydrogen ion record has been much less a problem of developing a

measuring instrument than of finding electrodes which will prove suitable in regard to being "fool proof" and requiring a small amount of expert attention.

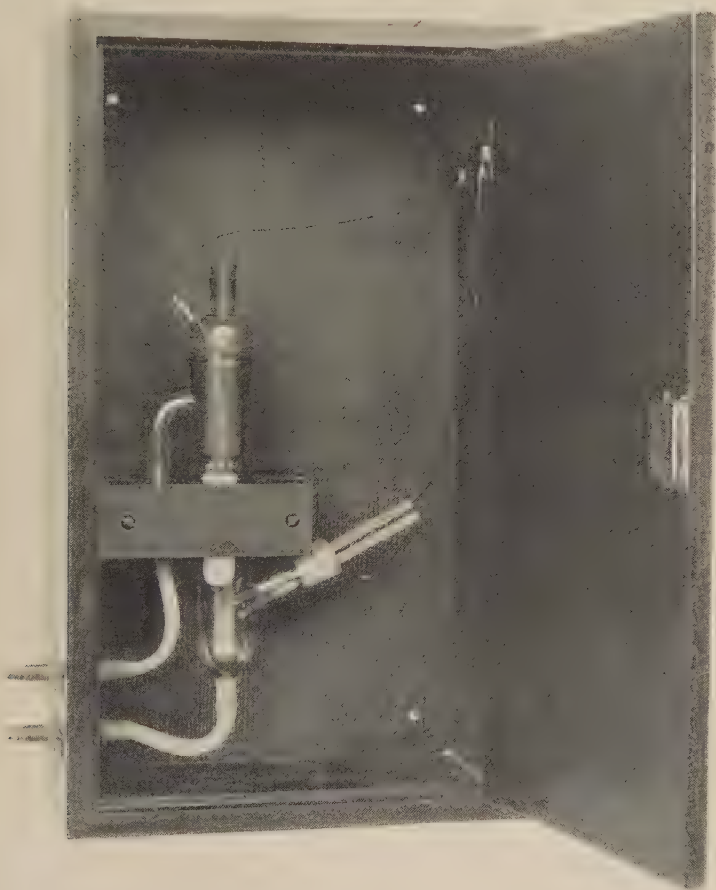


FIG. 2. MERCURY-CALOMEL HALF-CELL AND TUNGSTEN ELECTRODE

Several years have been spent in attempting to produce such electrodes and several new types have been developed. One of the most promising of the earlier electrodes was the aspirator type[8]

[8] Keeler, *J. Ind. Eng. Chem.*, **14**, 1010 (1922).

which was tested at the Montebello Filters, Baltimore Water Department. Sufficient accuracy was not obtained with this electrode, and too much expert attention was required in keeping the potassium chloride solution for the calomel cell flowing at the proper rate, in platinizing the electrodes, etc.

Experimenting with various electrodes it was found that the tungsten wire in an ordinary electric lamp would serve as an electrode in hydrogen ion measurements.[9] Later it was found that the addition of manganese sesquioxide in proximity to the tungsten, and a preliminary treatment in an alkaline buffer solution, would permit such electrodes to be used in more acid solutions and would increase their "life" and reproducibility.[10] Figure 2 shows the tungsten electrode and the calomel cell, the latter of which is another recent development.[11] The type of cell shown in this figure has been in use for about a year at the Montebello Filters and has proven far superior to any other type tested.

CARE REQUIRED BY THE APPARATUS

The attention required by the electrodes shown in figure 2 has been very much reduced. The calomel cell requires flushing and the introducing of fresh crystals of potassium chloride in the porous cup, approximately twice a week. The tungsten electrode has to be introduced into the cell about 24 hours before it is placed in service, but after it has reached equilibrium, it will give reliable readings for from two weeks to a month without any attention. Including the time required to take care of the recorder, such as oiling, filling the pen, renewing paper etc., the total attention required to obtain a continuous record of hydrogen ion concentration amounts to less than ten minutes a day.

The technique for making up the calomel cell is likewise simple. No standard solutions are required. The use of special grades of commercially purified mercury, electrolytic calomel and potassium chloride, in making up the cell, has been found to give a reproducibility considerably greater than that required for industrial measurements. A saturated solution of the potassium chloride is added to some of the mercury and calomel in the cell and, after shaking a few minutes, the cell is ready for service.

[9] Baylis, *J. Ind. Eng. Chem.*, 15, 852 (1923).
[10] Parker, *J. Ind. Eng. Chem.*, 17, 737 (1925).
[11] Parker and Dannerth, *J. Ind. Eng. Chem.*, 17, 637 (1925).

THE FLOW TYPE QUINHYDRONE ELECTRODE[12]

By the addition of an adapter and the introduction of a gold electrode in place of the tungsten, the flow type cell shown in figure 2 may be converted into a quinhydrone electrode. The quinhydrone (purchased commercially or easily made) is introduced into the adapter in small silk bags which require renewing about twice a week. This electrode reaches equilibrium more quickly and is somewhat more reproducible than the tungsten electrode. It may be used advantageously through a range of 3.0 to 7.5 pH, while the tungsten electrode is suitable from about 5.0 to 12 pH. It seems probable that the former will prove the more suitable for measurements in the raw water or in the precipitation with alum while the latter will prove the more suitable for controlling the addition of lime at the higher pH values. The quinhydrone electrode has the advantage of a lower temperature coefficient and likewise requires but small attention. Both of the electrodes appear to be especially free from the so-called "poisons" which affect the hydrogen electrode. The electrodes have been tested in the city water supplies of Philadelphia and Baltimore and tests are in progress in other cities.

In cold water a larger surface of quinhydrone must be exposed, in order to give a sufficient rate of solubility. However, this is much more convenient to accomplish than to regulate a dropping solution to the proper rate. The flow through the cell is regulated to about one liter in four to five minutes.

INTERPRETATION OF THE READINGS

It is usually convenient to have the scale of the recorder read in volts. If a definite electrode is to be used and the temperature is compensated, a scale reading directly in pH units may be employed. The voltage readings may easily be interpreted in terms of pH by the use of the chart shown in figure 3. It is seen from this plot that temperature has some influence on the readings. In water works practice, however, temperature changes are so slow that these are easily taken into account.

When the readings are made in terms of pH they have a perfectly definite meaning and can be easily correlated with such factors as

[12] For bibliographies on the quinhydrone electrode see Biilmann, *Trans. Faraday Soc.*, **19**, 676 (1924) or LaMer and Baker, *J. Am. Chem. Soc.*, **44**, 1954 (1922).

color, turbidity, or proper clarification. These factors are much less obviously related to such quantities as "monocarbonate alkalinity" or "free CO_2" with which quantities many workers still prefer to approximate hydrogen ion concentrations. Moreover pH readings can be easily reproduced by other workers in the same field while the

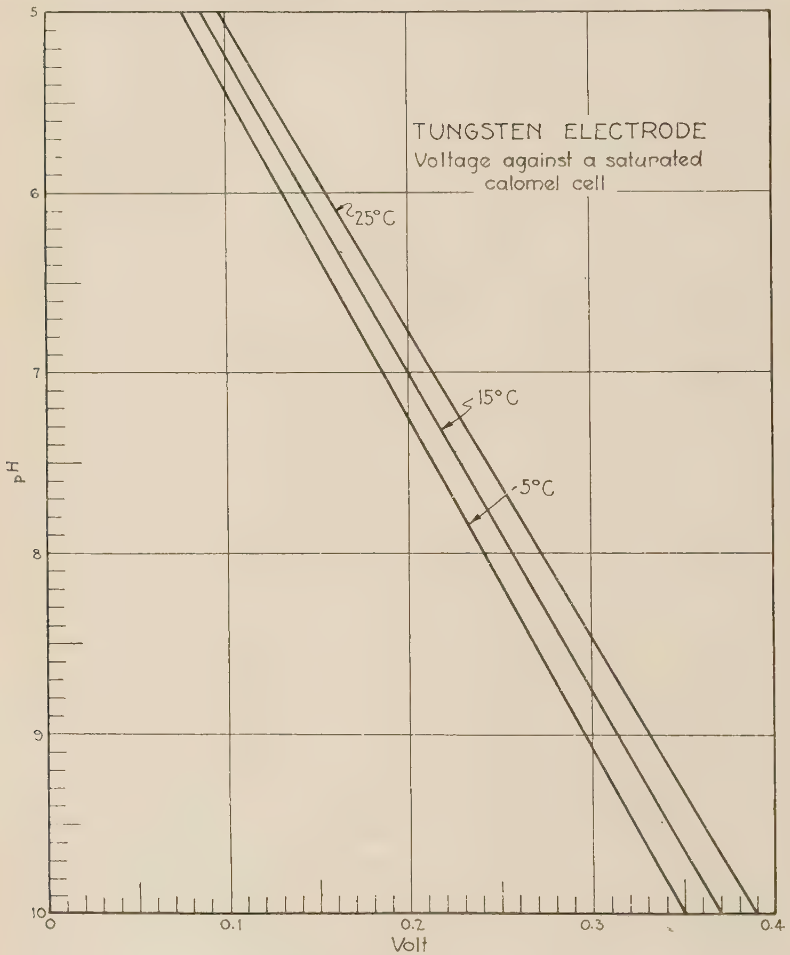


FIG. 3

quantities obtained by titration cannot be properly reproduced without a knowledge of the hydrolysable salts present.

The readings on the recorder may be interpreted in any terms desired. Thus, it is a simple matter to make an experimental

curve showing the relation between "alkalinity" and voltage of the electrodes, provided the water is being treated with a given chemical. The curve would vary somewhat with the alkalinity of the raw water, but changes in the latter would probably be slow enough to follow with ease. If the recorder readings are being used to control the addition of chemicals, either by signal lights or by an automatic valve, the setting of the control can be made to correspond to colorimetric pH measurements or to titration. This is easily accomplished by the "control point indicator" shown in front of the recorder in figure 1, since the "control point" can be readily adjusted to any value required. After two weeks to one month service the tungsten electrodes are found to drift very slowly towards higher voltages. If this drift is followed by changing the "control point" to correspond to the colorimetric pH or titration measurements, the electrodes may be used almost indefinitely.

ACCURACY OF THE MEASUREMENTS

From the experience gained with the tungsten electrodes thus far, it is evident that they are capable of an accuracy of close to 0.1 pH. This appears somewhat greater than the accuracy which can be obtained with colorimetric measurements upon potable water. When it is noted that a single small crystal of potassium chloride will frequently alter a colorimetric reading by 0.1 to 0.3 pH, that the color reading makes a fairly rapid shift of from 0.1 to 0.5 pH immediately after mixing, and that there is from 0.1 to 0.4 pH change produced in the reading by heating the tube with the hand (if the water is cold), a person becomes somewhat skeptical about the accuracy which is commonly claimed in colorimetric measurements. The authors made a series of colorimetric measurements on several samples of potable water using commercially purified dyes from two sources and commercial standards, as well as those freshly made up from buffer solutions. The average agreement in the measurements was not better than $\pm$ 0.2 pH. Dawson[13] has recently pointed out a source of error in the usual colorimetric method of measuring the pH of distilled water. Kohltoff[14] has also shown that considerable salt errors are present when measuring solutions poor in electrolytes by colorimetric measurements.

[13] *J. Phys Chem.*, **29**, 551 (1925).
[14] *Rec. trav. chim.*, **44**, 275 (1925).

From the authors' measurements with the tungsten electrode in potable water and from the frequent comparisons obtained with colorimetric measurements, the latter appear to give readings which average about 0.2 pH *high.* A possible explanation is found in the

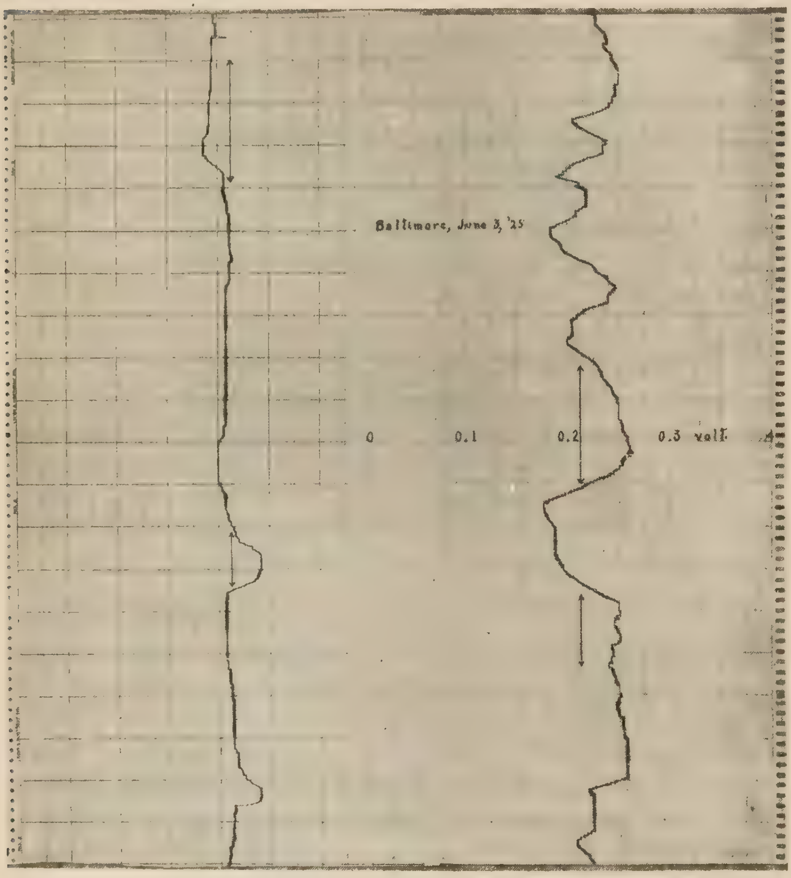


Fig. 4. H-ion Records at Baltimore

alkali which is usually added in making up the indicator solution. Even though the amount added is an equivalent and is supposed to form a neutral salt with the indicator, it is evident that such a salt would be highly hydrolyzed in solution and would be sufficient to cause errors in any slightly buffered medium.

In one experiment an alcoholic solution of an indicator was used and the results obtained were compared with those obtained with the alkaline salt indicator. In each comparison with potable water

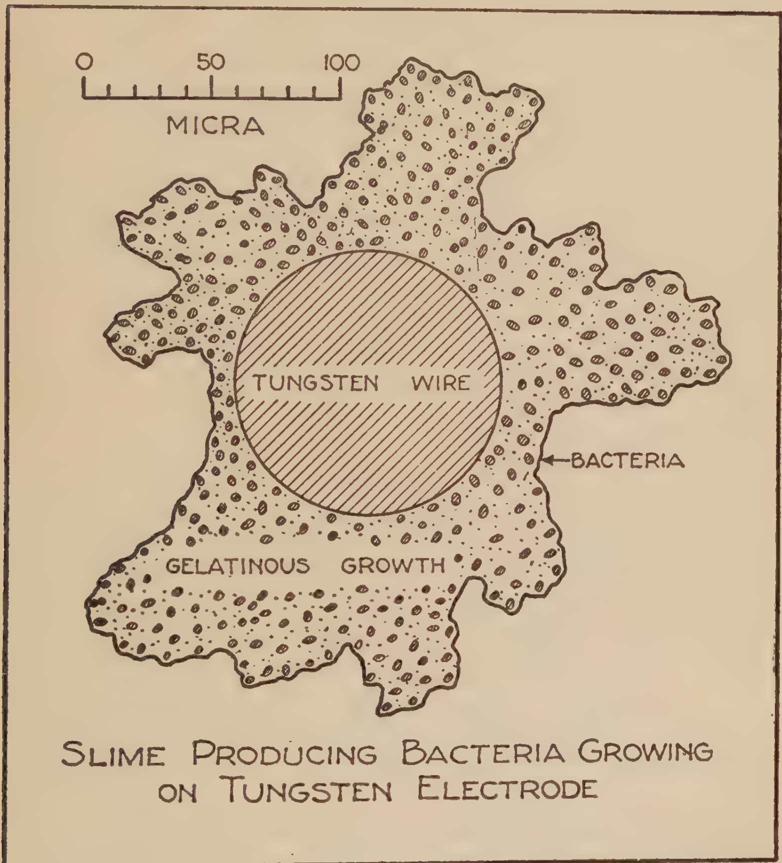


FIG. 5. Such bacteria may be of frequent occurrence in some public water supplies in the warmer months. They grow on all surfaces, and usually quite rapid. This destroys the sensitiveness of the electrodes and causes the voltage to drop; that is, the electrode drifts towards the acid sides. In such instances it is necessary to change the electrodes more often.

a difference of about 0.2 pH was obtained between the two indicator solutions. This experiment apparently confirms the explanation suggested above.

When accurate measurements are desired, the tungsten electrodes may be checked by standard buffer solutions without exposing the electrodes to the air. This is done by introducing the buffer at the bottom of the flow type cell by means of a rubber tube and funnel. Upon checking an electrode in this manner, by a buffer solution in the neighborhood of the pH of the potable water, considerable reliance may be placed upon the accuracy of the measurements.

Only one annoying electrode trouble has developed in the installation at the Montebello filters. During part of the warmer months, growths of slime producing bacteria sometimes occur. During this time a coating of slime was found to form over the tungsten wire, somewhat as shown in figure 5. This caused the voltage to drift away from the correct reading, and the drift seemed to be always toward a lower voltage. These biological growths usually last from one to two months, and at such times it is necessary to change the tungsten electrodes more frequently.

EXPERIENCE AT BALTIMORE

Hydrogen ion measurements may be used, not only to give information concerning the optimum conditions for precipitation, clarification, etc., but frequently they may be used to measure or control the application of chemicals. The latter is true, however, only in case the chemicals applied cause a considerable change in pH. This is always true in the application of lime and in some cases in the application of alum. When used in this manner the measurements are of the utmost value. When the chemicals are controlled from pH measurements, variations in the flow and of the concentration of the influent are evidently accommodated. Allowance is also made for variations in the concentration and the analysis of the applied chemicals. The latter point is especially important in the application of lime, since even with the best agitation there will be variation in concentration from the top to the bottom of a tank, or, if dry feed is used, in the density of the packing. If not used for actual control, the measurements can always be used as a check upon the application of chemicals and there are few plants in which such application is so precise that a check with an alarm device would not be valuable.

At the Montebello Filters the recorder is used to control the application of lime after filtration. A system of five signal lamps has been installed in the control room and this serves as an excellent remote indicator. A total of nine different positions on the scale can be

indicated. On account of the layout of the plant at Baltimore there is no way of obtaining a representative sample of the water soon after it is mixed with the lime. Consequently there is a time lag of twenty to forty-five minutes in the recorder readings. The operator consequently has to wait until the new opening of the valve has had time to affect the electrodes before he again changes its opening. With such a long and variable time lag it is probable that automatic control would prove none too successful and hence no attempt has been made at Baltimore to install such a control. Automatic control, with the new electrodes and calomel cells, has recently been proven successful in controlling the addition of lime in the Direct Oxidation method of Sewage Disposal.[15] This installation presented several difficult problems not met in water works practice and hence there would appear to be no difficulty in applying automatic control to water purification, provided the plant had a suitable layout.

Figure 4 shows two 24-hour records obtained at Baltimore. The record at the right represents a typical application of the lime as usually influenced by changes in flow, concentration etc., and that at the left was made while the operator was controlling the opening of the valve from the signal light indicator. On account of the time lag it is impossible to prevent fluctuations in the pH. However, the advantage gained in the latter control appears to exist primarily in *shortening the interval* of incorrect application. Thus, the record at the right shows that incorrect application frequently extended over periods of several hours, which is sufficiently long to have a considerable influence upon the clear water reservoir as a whole. The record at the left also shows periods of incorrect application, but these are shortened to about half an hour, and it is evident that these variations would be equalized in the reservoir.

One of the most important advantages gained by the introduction of the hydrogen ion recorder has been the psychological effect upon the operators. The type of laborer usually employed for operating chemical feed valves is frequently indifferent, unmechanical, and quite unautomatic. When no check can be made upon his work there is always a tendency for him to make no more motions than are absolutely necessary. Many plant managers would undoubtedly be very much surprised at hydrogen ion records which would show the non-uniformity of their chemical application of which they are now entirely in ignorance. But the importance of plant records are so

[15] Parker, *J. Am. Inst. Chem. Eng.*, Preprint, 1925.

obvious that this point needs no emphasis. The only thing which has been lacking has been the method of making such records and this need has now apparently been supplied by the apparatus described in this article.

SUMMARY

It is generally recognized that the hydrogen ion concentration is one of the most important factors in the proper purification of public water supplies. Apparatus is available whereby a continuous record of this important factor may be obtained with very little expert attention. This apparatus has been used for some time in controlling the addition of lime after filtration at the Montebello Filters. Records are given showing the more uniform chemical treatment obtained after the control was inaugurated. Automatic control appears feasible in plants having a suitable layout.

THE RELATION OF STORAGE WATER SUPPLY LAKES TO MALARIA[1]

By J. A. Le Prince[2]

With the rapid growth of our towns and cities the engineer is called upon to arrange for increased or new water supplies to meet future demands. Local conditions may make it advisable to increase the size of the existing storage water supply lakes or create new ones. The creation of such lakes may increase to a marked extent the prevalence of the malaria conveying mosquito (the Anopheles) in territory adjacent to the new or enlarged lake that may affect the malaria sick rate in families living within a mile of the flow line of the lake. There have been instances in recent years where most of the families have been so affected within two years after water was impounded. Such conditions often result in a number of law suits being brought against the parties who are responsible for creating the new lake or changing conditions in the enlarged one. Some of the legal action against the lake owners has been justifiable and some has not. There is always the possibility of the introduction of malaria into adjacent territory at the time the lake is formed. It is decidedly advisable to consider such matters in advance and cities building lakes should take precautions to protect themselves against unwarranted law suits. In some instances proper precautions are not taken because the engineers do not realize fully what conditions are favorable to the maximum production of malaria conveying mosquitoes.

As a general rule, conditions in a newly formed lake are most favorable to mosquito production during the first three years. In case we desired to produce a maximum of mosquitoes, a very good method would be to impound the water during June, July and August.

In the newly formed lake there is a considerable amount of floatage and debris that affords protection to the mosquito larvae as well as growth of algae (spirogyra) in which the mosquito larvae collect and where their natural enemies can not get at them.

[1] Presented before the North Carolina Section meeting, September 16, 1925.

[2] Sanitary Engineer, United States Public Health Service, Washington, D. C.

Of course, during the first or first and second year of the lake there is a marked absence of natural enemies of the mosquito larvae. That condition makes it desirable and often essential to supply an abundance of small mosquito destroying minnows. We find the Gambusia affinis, the pot bellied top minnow, is the best fish to use for this purpose in the South. It is advisable to use large quantities of these fish and to establish hatcheries for them near the site of the proposed lake, whenever possible several years before the lake is made. This question is covered in an article soon to be published in the 1924 proceedings of Malaria Field Workers, U. S. P. H. S., Washington, D. C. Under no circumstances should new lakes be stocked with bass or pike which destroy the Gambusia.

In general the lake which has an approximately constant level is more favorable to mosquito production than one with a fluctuating level. The more free the edge of the lake from floatage, aquatic growths and algae, the less favorable it becomes to Anopheles development. In most instances it is advantageous to keep the water 2 feet or more above maximum level during the non-mosquito months. This allows the wind and waves to strand the floatage on shore, kills vegetation, and permits the water body to be drawn down to a clean edge when the mosquito season starts. This clean edge affords very little or no protection to the larvae and fish get nearly all or all of them.

In clearing lakes of trees and brush it appears to be common practice to begin operations close to the dam and to lose interest as we get toward the upper end of the lake or of its arms. So far as mosquito elimination is concerned it would be much better to begin operations at the upper end of the lake and to be particularly careful to make a good job of clearing the upper end of each inlet. It is these inlets and particularly their upper ends that are most apt to produce mosquitoes and most certain to hatch law suits.

It is only that which pierces the water surface, such as brush, branches, rank vegetation, etc., or floats on it and either anchors floatage or gives protection to Anopheles larvae that we are interested in. Larvae do not collect around tree stumps unless they anchor floatage.

No matter how carefully a lake is cleared there is always a potential danger and periodical inspection is necessary during the first two or three years. Considerable floatage may be carried into the lake from the river or streams that feed into it, and such floatage

must not be allowed to collect in the lake and become a source of Anopheles at places within flight range of residences. It must be removed. Certain aquatic plants or their seed often get into the lake and such growths should be removed at once before they become numerous and costly to remove or control. Low places that become isolated ponds as the lake level lowers should be connected in advance to the lake by ditches so fish can enter them.

If in spite of all we do it is found that Anopheles production continues, then, if these mosquitoes can reach habitations, we must apply oil or other larvicide to the water surface, and in such instances it would be advisable to consult with the state board of health as to the most satisfactory and economical procedure.

Where any portion of a lake is producing Anopheles in fair numbers or in quantity, the adults may be found in shaded places in the daytime, in hollow stumps, small caves, under logs, etc., where they find sufficient shade from light and wind. We call such places Anopheles measuring stations.

The United States Public Health Service has been studying the relation of impounded waters to malaria outbreaks and malaria prevalence for a number of years. In Alabama, South Carolina, and Virginia the state health department regulations for the impounding of water are based on these studies.

In 1917, the Conference of State and Territorial Health Authorities discussed the advisability of having legislation enacted, which would permit the impounding of water on a large scale only after a license was obtained from state health authorities, which would prescribe certain conditions to minimize or prevent the danger of spread of malaria, and later the Public Health Service took this matter up again with the state health departments.

A brief outline of regulations is given below.

SUMMARY

1. It is not good engineering practice to endanger the health of rural population in our efforts to improve the health status of the urban population.

2. In impounded water projects the cost of removal of floatage, aquatic growth, clearing of inlets, inspection for collections of floatage, start of growths of cattail and other aquatic plants, and Anopheles elimination, should be included in the original plan and estimate.

3. In areas previously non-malarial, though Anopheles were pres-

ent, an epidemic can be created by the importation of malaria infected labor, and malaria prevalence can extend far beyond the flight range of Anopheles from the lake.

4. A high water level in the winter months will often reduce cost of removal of floatage and will reduce mosquito production.

5. Wherever possible Gambusia hatcheries should be established two summer seasons before water is impounded.

6. Provision should be made for constant periodical inspection of newly formed lakes. The inspector must know or learn habits of Anopheles larvae and be interested in their elimination. He should keep all floatage treated with oil or larvicide until it can be removed, and leave no places (where mosquito larvae are present) untreated.

7. The engineering division of our hydro-electric power companies have found the above to be good engineering practice and that its neglect is decidedly expensive procedure.

8. Bulletins and reprints on the relation of impounded water to malaria and relative to control procedure have been published by the United States Public Health Service, Washington, D. C. and may be had on request.

OUTLINE OF REGULATIONS FOR IMPOUNDED WATERS

1. Wherever impounded water projects are to be located under the provisions of this act in those parts of the United States in which malarial fevers exist, or malaria bearing mosquitoes are known to propagate, the following general measures shall be enforced for the protection of the public health:

(*a*) All laborers employed in the construction of the dam and the impounding of the water, shall be housed in properly screened houses and such steps taken by quinine administration and control of mosquito production in the vicinity of the camps as may be necessary to prevent the infection of malaria mosquitoes and the introduction of malaria into this locality.

(*b*) In the area to be occupied by the reservoir, its branches and indentations, all brush, trees, undergrowth, logs and similar objects, which if not removed would float on the surface of the impounded water and thus constitute conditions favorable to the production of malaria mosquitoes, shall be removed, burned or otherwise disposed of prior to the closing of the dam and impounding of the water. All trees or underbrush shall be cut sufficiently near to the surface of the ground to prevent their standing above the surface of the water at any and all stages of the water, and thus holding drift and floatage.

(*c*) The formation of log jams and the collection of drift and floatage in narrow valleys or indentations and along the banks of the reservoir where wave action is absent or weak, shall be prevented during the mosquito season.

(*d*) Insofar as practicable, the water level in the reservoir shall be fixed

so as to reduce to a minimum shallow, submerged areas on which aquatic plants will grow and reach the surface of the water.

(*e*) When practical the water level in the reservoir shall be held about three feet above normal high water level from December until the Anopheles breeding season in spring or early summer. After that time fluctuation is desirable.

On gently sloping banks or where stranding of floatage is practical, before the water is impounded the shore line shall be cleared of all undergrowth, brush, trees and logs, to facilitate the stranding of floatage, for a distance of about fifteen feet back from normal high water level.

During the first three years of the lake, its owners shall arrange for its constant inspection during the mosquito breeding season, and all sources of mosquito production shall be promptly eliminated or treated with larvicide.

(*f*) The reservoir shall be adequately stocked with top minnows which feed upon mosquito larvae and every effort shall be made to protect them against their enemies and secure their successful propagation.

(*g*) All separate pools and seepage places created during the construction of the dam or by the impounding of the water, whether adjacent to the reservoir or situated in the stream bed below the dam shall be filled, ditched, oiled, or stocked with top minnows (gambusia) in order to prevent mosquito production.

2. Whenever an impounded water project is to be located under the provisions of the Act aforesaid, the licensee shall obtain a permit from the State Board of Health and carry out such measures as the State Board of Health may determine to be necessary to prevent pollution of the drainage shed, or likely to cause or aggravate danger to the health of persons living near the lake.

3. The foregoing rules may be amended from time to time as necessary within the discretion of the State Board of Health.

REPORT OF STREAM GAGING COMMITTEE, NORTH CAROLINA SECTION, 1924–1925[1]

Your committee presented last year a report describing in detail the vital necessity of additional data on the flow of streams used or likely to be used for municipal water supplies. The experience of many municipalities in the state during the past year has served to give a strong emphasis to the need for such information. Had it been available, there is little doubt that some of our cities would not be facing the present acute situation relative to their water supply today. The committee recommended, and the Section endorsed the report, that the state appropriate at least $40,000 per year for coöperation between the State Department of Conservation and the United States Geological Survey in stream flow and allied hydrological investigations. The Legislature appropriated a little over $8000.

What has been the result? A critical period has occurred in the flow of many of our streams due to the extreme drought conditions. It became imperative that as many measurements as possible be made of this crucial flow. During the month of July, 53 measurements were made, and during the month of August, 65 such measurements of extreme low flows were made on streams all over the state, from Murphy to Roanoke Rapids. As a result travel funds have been depleted to such an extent that the regular measurements necessary to the rating of the existing gaging stations will have to be seriously curtailed, and if floods occur it will be impossible to make trips to measure them during the present fiscal year. Absolutely no additional gaging stations can be established, in spite of the request for them on the part of municipalities and others. Mr. J. H. Morgan, experienced office engineer, has had to be released from the Asheville office, due to no funds with which to continue his salary. As a result the compilation of stream flow data is considerably delayed and current information cannot be furnished to municipalities with the requisite promptness.

At the time of the committee's report last year there were in opera-

[1] Presented before the North Carolina Section meeting, September 16, 1925.

tion in the state 34 regular gaging stations of which four only were equipped with recording apparatus. At present there are 53 regular stations, of which 13 are equipped with recorders. This indicates, in the opinion of the committee, a most praiseworthy accomplishment of the stream gaging authorities acting under severe handicaps. As indicated above, the limit to additional stations has been reached because of lack of funds.

The committee desires to commend the City of Durham for its action in appropriating $2000 for extensive stream gaging, rainfall and evaporation studies to be carried on by the State Department of Conservation and the United States Geological Survey. It appears likely that the City of Greensboro will undertake a similar investigation. It should be pointed out, however, that the appropriations from these cities are for materials and labor only. The cost of design, supervision, operation, and compilation of records are carried by the state. Lack of personnel and travel funds has prevented the establishment of these stations for several months after the local coöperation has been secured. No more such joint investigations can be undertaken, due to lack of funds to carry the overhead on the part of state authorities.

The committee recommends that there be appointed a Standing Committee on Water Resources and Forestation, that this committee begin to function at once by getting in touch with water works superintendents, engineers, city officials, and others to impress upon them the importance of having the next Legislature carry out in principle the recommendations of this committee adopted by the Section last year.

The committee further recommends that the Section endorse the bill prepared by American Engineering Council for introduction into Congress providing for a uniform and increased investigation of the water resources of the country.

Respectfully submitted,

D. M. Williams,
M'Kean Maffitt,
Sherwood Brockwell, *Chairman.*

FOAMING IN COAGULATING BASINS AND AIR BOUND FILTERS[1]

George D. Norcom:[2] I have had foaming, but I always felt very good whenever I saw it, because I always found, when the chemicals were re-acting very well, it was a usual thing for foam to begin to form in the mixing chamber, that is, just great masses of dark brown colored foam would climb up out of the top of the mixing chamber. In fact, it might be carried out to the sedimentation basin. We find when the wind is blowing rapidly it will shower the foam like snow-flakes all over the place. I am not prepared to say definitely what the cause of it is. My own hypothesis is that under certain conditions of temperature, surface tension and other physical phenomena, the carbon dioxide formed by the reactions of alum and natural alkalinity rises through the surface scum and causes the formation of the bubbles.

The reason I say that I think it is a good sign is that usually when you get that condition your chemicals are reacting very thoroughly; there is little free alum left in your filtered water. In other words, the reaction is complete, the alum is being completely precipitated, which is the thing you are after.

Since the treatment of water is a chemical process, and this foam is a natural by-product, as I think it is, even though it does look a little bad to visitors, if it is explained to them as being nothing at all except harmless foam and the natural resultant of the chemical treatment, why should they find any cause to become alarmed or consider it as disfiguring as the natural brown stains you frequently get around your filters. No matter how hard you scrub or wash, you will have them. We do not like the looks of those and we have men scrub them off with steel brushes and paint the surface with cement to make it look white. Still, it is unsightly, although it is merely the colored matter and the iron in the water precipitating out which causes that discoloration. I think the same thing can be applied to the foam.

[1] Topical discussion before the second annual conference, Filter Plant Operators, North Carolina Section, September 14, 1925.

[2] Superintendent of Filtration, Wilmington, N. C.

As to air bound filters, we have also had some trouble. You all know the phenomenon. The filters are apparently working beautifully. Suddenly you discover you are not delivering any water. Your loss of head is running up high, and on cutting it off you get a great rush of air from the interior of the filter, breaking up the surface. If you were not going to wash it, anyway, you would have to wash it then. Some say that is the natural air dissolved in the water which is liberated under the uneven pressures which vary from the atmospheric pressure to those developed in the lower part of the filter. Others claim it is due to the dissolved oxygen in the water which may be released by reduction in the pressure.

I have never analyzed any of that air that comes up out of the filters and I am not prepared to say whether it is natural air or whether it is largely oxygen. But as far as any remedy for the thing is concerned, you can try cracking the filter, that is, just cracking it and putting it back into service again, which will get rid of the air. It generally produces a mighty bad effluent, and I can not use that system on my filters. If they get air bound, I crack them, but it is a hopeless proposition for them ever to come clear again.

About the only other thing you can do, that I know of, is to wash them. But, fortunately, I have never had the condition persist any great length of time. That is, we might have some trouble with a few filters for a short period of time, but, as a rule, the air binding is not serious enough, in my case, to make it a bad situation.

A. O. True:[3] With reference to foam, I think foam, as we ordinarily see it in a filter plant, is merely a mixture of gas and suspended matter, probably finely divided clay, which gives it this brown color, and coagulant, which is a slimy material. The combination of those three materials forms what appears to be foam.

There might be several sources of the gas. We can understand where the coagulant and where the clay comes from, but there may be several sources of the gas. One source of the gas Mr. Norcom already mentioned as the natural carbon dioxide which is liberated by the chemical reaction when aluminum sulphate is introduced into your alkaline waters.

A second source of gas which would form foam could be from the condition of your water. Water has a saturation point for air. It

[3] Sanitary Engineer, Proximity Manufacturing Co., Greensboro, N. C.

will dissolve a certain amount of air, under different conditions of temperature and pressure, and it is a common thing to observe water when those conditions are over-balanced. For a given pressure or a given temperature, or a combination of the two, water will dissolve a certain amount of air. If those balanced conditions are overthrown, air precipitates out in very fine particles. These finely divided bubbles give it a milky appearance. So that temperature would change, if the water had been under pressure coming from a reservoir and suddenly that pressure was released; or if a change of temperature came along, it is readily understood that the air might separate out, and becoming mixed with the finely divided matter would carry to the top.

A third source of the gas might be decomposition. We spoke of it this morning as decomposition of the sludge which would give off methane gas or carbon dioxide, or both.

I agree with Mr. Norcom that, while foam is rather an objectionable thing to the average layman, it does not really amount to anything. It does not interfere with any processes, apparently, and if it gets washed away from the sides of the filter and the various surfaces it collects on, I can not see that it is very objectionable.

George F. Catlett:[4] There are two conspicuous facts about foam. One is that it is more prevalent with the colored water. It is present in practically all colored waters, and persists longer and is worse, although I have seen it in connection with some waters that had no color in them.

You will also notice it in hot weather more than in winter. The foam, itself, is coagulant. I have taken some of it and examined it and found it to be coagulant.

As I said this morning, the floc that you get with the colored water is a good deal more feathery and lighter than you get with clear water. It is almost impossible to get that fine, pin-head floc on the colored water. If you get floc at all, it comes in these large, light, feathery pieces. With that foam, of course, there is always an ebullition of air. I think the reason the colored waters get it more than the others is due to the fact that the coagulant is light and the bubbling of the air set free, which you will always find with the foam, is better able to raise it than the heavier clay floc.

The worse case of foaming that I ever saw was on a water that

[4] Sanitary Engineer, State Board of Health, Raleigh, N. C.

was not colored. It was a basin that was heavily baffled. It was baffled so heavily that it was almost a mixing chamber, and on ordinary conditions the old floc would keep in suspension, would keep rising up and gradually the smaller pieces would conglomerate so that it would be in large chunks.

The question of foaming is a question closely allied to air bound filters. Foaming is due pretty much to that, outside of the nature of the floc.

In this plant that I was speaking of, we were called by the superintendent. He said his filters were getting clogged up and he only got a half hour's run. At the end of a half hour's run his rate would fall off and in less than an hour he could hardly get any water through the filters. Just before that we had a similar experience where the condition was due to cyclops and microorganisms in the water. I thought that was also the case in this instance. It was in the same locality.

As soon as I shut the filter off, the air boiled out of the filter. On examining the bed, it was found to be perfectly clean, and microorganisms had nothing to do with it.

I went out to the coagulating basin. It was boiling like a potato on a fire. It was carrying coagulant up and foaming. The foaming was rising up and going over the basin. They had men with shovels out there, and the whole ground around was covered with what they had shoveled off. It was about the most extreme case of that kind I ever saw. At the same time, the plant was getting a rather heavy, feathery floc. It was clay water, and ordinarily they can get a fine, heavy floc, but they were getting this feathery floc.

The foaming is due, therefore, to the ebullition of air with very light coagulant. With entrained air it forms a foam on top of the basin. It does no harm. I know no way to prevent it, except to shovel it off.

In regard to the air bound filters, first I thought it was because of the hot weather. I thought there was some vegetable decomposition there and probably carbon dioxide. The carbon dioxide was down to about 6. At that time the thing disappeared in a short while, with a rain, and we did not get a chance to examine the gases coming off. But later on at that same plant, when we had a similar trouble, although not such an extreme case, we did examine it and found that it was air that contained oxygen in just about the same proportion as ordinary air.

Mr. Lasker, of the Raleigh plant, made some tests a short time ago to determine the total dissolved oxygen in the water before and after it went through the filter. He had, in his basin, where it was bubbling, a super-saturation of about 110 per cent. When it reached the filters, I think it dropped to about 85 per cent. It came through the filters with about 76 per cent, approximately. We made a determination of the gas that was coming off, and found the proportion of one to four oxygen and nitrogen was about right, as existed in all waters. Carbon dioxide had not increased.

Another thing I have noticed about effusion of gas is that it is much more prevalent in plants where they have a large and very shallow reservoir of stored water. One of the worst places where I have observed that is at Henderson, where the reservoir covers a wide area, but is very shallow. The water is exposed to the action of the sun, and on the hottest days the effusion of air is worst. Following a rain, or where the temperature changes, there is an immediate cessation of gas ebullition.

In connection with Henderson's reservoir there is some spring water feeding the reservoir that is usually at a very low temperature, and evidently contains fairly high oxygen content.

A. O. True:[3] I would like to ask Mr. Catlett, in that case he cited of extreme foaming, was that a permanent or just a temporary condition?

George F. Catlett:[4] It only lasted a few days and then disappeared, following a heavy rain.

A. O. True:[4] During the warm weather?

George F. Catlett:[3] Yes.

Mr. Meredith: I have considered whether that condition might not be brought about by fertilizers put on the water-shed. It seems to me that more of our water-sheds are being cultivated every year. It is a fact that we did not get that trouble when we first commenced, but afterwards it developed and has been with us ever since. I just wondered if it might not be from certain fertilizers.

E. G. McConell:[5] I would like to ask Mr. Catlett whether or not,

[5] Superintendent of Filtration, Water Works, Charlotte, N. C.

during this period of excessive basin foaming, there was any indication of air binding of the filters.

George F. Catlett:[2] That was the time I was called upon to investigate the trouble with the air bound filters, and found the basin foaming.

E. G. McConnell:[5] At Charlotte, we have a water that is easily treated. We were operating the old wooden tub filter and we never had any trouble with air binding in those filters. The first year we have been operating at our new station, which has the under-drain system, under those concrete units, we have experienced trouble. However, I do not think that there can be any definite conclusion as to relation drawn there, because of the fact that, at the same time, our raw water was changed from the open river into a large reservoir, caused by the building of a hydro-electric plant just below us, and the location of our intake just adjacent to this dam.

At any rate, during the winter months, when the turbidity ranges from 50 to 400, we get filter runs as high as a week, without ever getting a sufficient loss of head to wash the filters.

As soon as this dry season started, this spring, and our turbidity began to drop below 50 or 40, we began to experience this trouble. Our filters would air-bind in six hours. As Mr. Norcom suggested, we first cracked those filters to get rid of the air, and placed them back in service. But that certainly is not a satisfactory means of handling it, so we immediately changed our procedure to simply washing the filter, even if it did take more wash water. It is better, in the long run, to wash it out. At certain times those filters were so air bound that when we merely shut off the filter our air would come up without even draining down. In other words, the air would rush up before we even let the filter down. It would vary. Of course, some filters would begin to bubble up before we could let it down. In each case, however, just as soon as we reversed the flow of water, we of course had a rush of air.

We have installed now an apparatus for making dissolved oxygen tests. We are going to see if we can find out anything along that line. We have made a few tests, but not enough from which to draw any conclusions.

I also made another little experiment there. Our under-drains are so constructed that the effluent therefrom is through a cross which connects to the underdrain system, through a concrete wall about

eight or ten inches in thickness. On top of this cross it was level, or a little bit higher than the top of the under-drain system. I naturally concluded, therefore, if there was any air in the under-drain system itself, I could get some by tapping this cross, because it was as high as, if not a little higher than, any part of the under-drain system. But when I tapped it I could not get any air, regardless of how highly air bound the filter was. I concluded, therefore that this air must be in the sand bed itself, and not in the under-drain system.

A. O. TRUE:[4] I would like to ask what rate your filters were running at the time you had this air trouble?

E. G. MCCONNELL:[5] Normal rate.

A. O. TRUE:[4] Some years ago, George W. Fuller pointed out, in connection with the air binding of filters, that the plane, as he called it, of maximum resistance in a filter was near the sand surface, and if the air particles were located or rose in that filter to a point at or near the sand surface, very serious air binding would take place; but if those air bubbles were located at a lower plane, they would not be so serious—it would not cause such a loss of head. He pointed out also in a filter running at a rather rapid rate, say a normal rate, that air bubbles would be carried to the lower strata of sand and might even be carried through the under-drainage system and pass out with the effluent. Probably often that would be a continuous process. Air bubbles, as fast as they were being formed, instead of binding the filter, would be carried out in the effluent. Whereas, if the rate of filtration had been much lower, the bubbles would have risen in the sand bed where they would cause the resistance which we get, probably, when the filter is air bound.

E. G. MCCONNELL:[5] I am very much handicapped at Charlotte in not having any rate of flow gauges on our filters. Of course, we have a means there of regulating the flow of the filter by an orifice. But since that changes during twenty-four hours, according to the amount of water we have in our clear water basin, it causes the head to vary on the controller. The rate of flow changes and we have no rate control.

Now, I have noticed that, over a holiday or a Sunday, we do not

have as much trouble with air binding. The filters will run for a longer period than when they are running normally through the week, which shows that the more water you pass through the filter, the more air you are going to liberate. I am pretty sure that it is either dissolved oxygen or air that is liberated in the sand bed itself; that is, it is entrapped in the sand bed.

L. L. HEDGEPETH:[6] Our pumping plant is located on the creek. We take water from the creek direct. When the creek is low, and the intake pipe is not full, I get air binding in the filters. When the creek is high, I do not get it.

E. G. McCONNELL:[5] The head of water coming into our plant is practically uniform, because we store it in a basin which will hold about a seven days' supply. Even after it comes from this hydro-electric dam, it is stored again for about a week before it comes to our plant. The level in this storage basin is kept uniform, of course, within reasonable limits. We take it by gravity from this basin, by a twenty-four inch cast iron line.

So I think that in our case it evidently is the nature of the water itself. The dissolved oxygen or the entrainment of air must vary somewhere beyond our plant.

W. H. WEIR:[7] Mr. Baylis of Baltimore had some experience on filters, and he decided to go back further and look for the trouble. He found a peculiar situation at his intake. Since the pumps churned the water up in very small bubbles, he carried out a series of experiments to determine the amount of air which could be held in small and in large bubbles. Mr. Baylis has since published an article in Industrial and Engineering Chemistry. He said his trouble was entirely from the intake. When he corrected that, he got rid of almost all of his troubles.

E. G. McCONNELL:[5] Our conditions are so uniform at Charlotte that we have the same pumps going all the time, and supposedly they are packed about the same. I do not think there is any question, if the packing glands are not correct, that you can have a lot of waste

[6] Thomasville, N. C.

[7] Assistant Engineer, State Board of Health, Raleigh, N. C.

while your pump is down and you will pull in air while it is running. Our intake, being submerged several feet, should not cause any churning. We do, however, discharge into this storage basin through a series of six-inch nozzles turned up, and it merely overflows through those nozzles. But that goes on all the time. All the water is discharged that way. So I am inclined to believe that our trouble is probably before it even gets to our river intake.

A. O. True:[4] There is another source of air which I do not think has been mentioned, and that is in leaky filter connections. When the filter is operating under a negative head, you have a less than atmospheric pressure in your filter connection and in your controllers, and if there is any leak, or leaks, in those, air will enter at that point. It is reasonable to suppose that that will continue on and get into the filter.

T. C. Patterson:[8] When the construction engineer of the Norwood Company installed our filters with a three-quarter galvanized pipe from a short tube on a loss of head gauge, he brought it through the wall with a sand strainer on it. It was about 4 inches down in under the sand, and before we got to operating there Mr. Weir came down. We had trouble with No. 2 filter. It was air bound and when we cracked the wash line, it bubbled up. Thompson came back and our walls were leaking badly. He said he thought it was the walls, but I did not see how that could be because the pressure was out. In working around this loss of head gauge, I discovered that the short tube was sucking air and you could hear it gurgling and bubbling. I told Thompson about it. He did not think that was it. But Mr. Weir had gone away and left instructions when he came back to take that three-quarter pipe out of the sand bed and put the strainer on behind the rear wall. Immediately after we did that we had no more trouble with that filter. This pipe was about an inch or two inches deeper in the sand bed on No. 2 filter than on No. 1. I think that is where that air came from. The filter was sucking it from the loss of head tube.

E. G. McConnell:[5] Mr. Patterson, you are located on the same water supply as we are, a few miles below us. Do I understand you have had no further air trouble after you took out this tube?

[8] Superintendent, Water Works, Mt. Holly, N. C.

T. C. Patterson:[8] No, I have had no further trouble after taking it out.

J. H. Suggs:[9] I have had some trouble once or twice, and I found that all my trouble was in the controller. The air lands on your controller and accumulates and backs up on your filters in some way. I stopped the leaks around the controller and I have no more trouble.

E. S. McConnell:[5] In view of the fact that at Charlotte we got along with our weekly run one season of the year, and at another season of the year we could have a six hours' run, I am still inclined to believe it is something else besides leaks around our filters.

I am making dissolved oxygen tests, as routine tests for next year, and hope to have something definite along that line for the next meeting.

T. C. Patterson:[8] I am only about three or four miles below you. Wouldn't I have about the same trouble you have, if it is caused by oxygen?

E. G. McConnell:[5] You ought to have. Maybe your filters are different from mine.

S. F. Catlett:[3] There is a difference. Your water is taken right directly from the river.

E. G. McConnell:[5] It is taken from below this dam.

S. F. Catlett:[3] You have a storage reservoir in between.

Talking about rate controllers, they are supposed to have a seal on them. We have found on several occasions that the seal was incomplete. If that seal is incomplete, it will certainly take air. That is a common cause of air trouble with the controller.

[9] Water Works, Durham, N. C.

STERILIZATION OF WATER MAINS AFTER LAYING[1]

By C. W. Absher[2]

It is well known that the pollution of new water mains is almost unavoidable as the ditches are sometimes dug through mud and all kinds of disagreeable filth. Even in dry ditches, however, there is always a chance of contamination from the soil that would at least result in a good many cases of diarrhoea. No one knows what disease the workmen themselves may have or what kind of an epidemic they might start from handling the pipe.

Therefore in order to protect the consumers from these possibilities, why not take advantage of the well known sterilizing properties of liquid chlorine? The dosage can readily be checked by the orthotoluidin test just as it is at the purification plant. This paper however need not go into that part of it, but will try to suggest some new idea for the appliance of the chlorine.

It seems best that a considerable time should elapse after the chlorine is applied to the new main before it is put in service. This gives more safety to the procedure and allows more time for the mechanical tests of the main. The simplest way to gain both these ends is to test the water main after each day's laying by means of a detachable test plug with a rubber gasket that can be clamped in the bell and or, if necessary, on the spigot end of the pipe, These plugs have a threaded orifice in which a short nipple and stopcock can be inserted to rid the main of air. The tank of chlorine can be connected to the main just beyond the point where the new work started by means of an ordinary corporation cock. Then the water and chlorine could be admitted simultaneously, leaving the chlorine on until the orthotoluidin test shows complete sterilization. The water for the test being taken from the orifice in the plug.

The passage of the chlorine through the corporation cock would probably ruin it, if it is not cleaned up soon afterward.

[1] Presented before the North Carolina Section meeting, September 15, 1925.

[2] Superintendent, Water Purification, City Water and Light Department Mt. Airy, N. C.

DISCUSSION

W. E. VEST:[3] My experience has been that the sterilization of water mains after laying did not have as much attention long ago as it probably should have had. It is not the custom, in the city from which I come, to go to any great expense or any great time for sterilization, though the mains are very thoroughly washed by flushing for quite a while.

I will be glad to hear from members all over the house as to their practice, in their cities, and also the necessity for sterilization of new mains.

C. S. LOGAN:[4] I think that is very essential, although they do not do it out at our place. I had a break between my filter plant and the reservoir in town, and we had to repair it at night right in the swamp, and I know we got infection through that. If we had an arrangement there to sterilize, that would not have happened.

H. A. LILLY:[5] We had a little experience last spring along that line. We put in a new water main over a distance of about a mile and a half, and previous to putting that main into service we flushed and put in clear water for something like an hour and a half. We did not disinfect, and the next day we found bacteria in our mains, which necessitated going through our clear water storage basin and dumping the disinfectant in.

M'KEAN MAFFITT:[6] I am glad this subject has come up. I have been laying water mains for twenty-five years, and I have been in a rut like all the rest of them. I have never sterilized the main. But I will never lay another one without sterilizing it. I will give two illustrations here as to why they should be sterilized.

We were laying a 6-inch main in Florence, S. C. One night, as we knocked off, one of the negro laborers took off his work-shoes and stuck them in the end of the 6-inch pipe. We did not know the shoes were in the main and the next morning started in the usual manner laying the pipe. We got to the end. We started to flush out the main

[3] Superintendent, Water Works, Charlotte, N. C.
[4] Superintendent, Water Works, Waynesville, N. C.
[5] Tallassee Power Co., Badin, N. C.
[6] Superintendent of Water and City Engineer, Wilmington, N. C.

in the usual manner. We were getting a fairly good representative flow when suddenly, with somewhat of a crash, the flow ceased. Two joints were blown out. Immediately the flow started again and ran for probably a second, and then stopped the second time with another crash. At the second crash, the water hammer broke the hydrant in two.

The foreman in immediate charge of the work, at the first stoppage of the water, went to the valves at the starting point and started to close them, so we did not have very much trouble with the line with leakage. We found the pair of shoes of the negro laborer that had dammed the water completely and caused the water hammer to blow out the two joints and the second time to break the hydrant in two and crack the flange at the base.

If a pair of laborer's shows can get into the water main while you are laying it, how many bacteria may be on those shoes or get into that main from other sources.

Another instance happened in the same town. A nice, white, large leghorn hen escaped from the neighborhood poultry yard and the children were chasing that hen through the street, trying to catch it, and ran it into the ditch and she ran into the end of the 6-inch pipe. We happened to know that the hen went into the pipe, so we went down the line and opened the 6-inch valve and blew the lady out.

I asked the chemist on the building of the plant to express his opinion—I had great confidence in that gentleman's ability as a bacteriologist and I wanted him to express his opinion on the danger of bacterial infection from newly laid water mains that are not thoroughly sterilized.

George D. Norcom:[7] As Mr. Maffitt has already told you, we were not in the habit of sterilizing any new mains, and at the first flush the thought occurs as to how the thing could be done most easily. I do believe that they should be sterilized. The illustrations already given are sufficient to emphasize the need of that. And then, of course, the pipe, as it comes to us, is likely to be in bad condition, contaminated one way or another, to say nothing of what might get into it during the process of laying. So that it seems to me it should be sterilized.

I had intended to say something more, or make some remarks,

[7] Sanitary Engineer, Board of Health, Wilmington, N. C.

after the paper on "Freshly prepared hypochlorite solution," by Mr. Lilly, because it may not be exactly practical for everybody to have a portable chlorine machine that could be taken to the city of the newly laid mains for the application of chlorine.

In France, they use a solution of sodium hypochlorite and since the war that material has become available in this country. It is rather an alkaline solution of sodium hypochlorite and it is sold in this country under the name of D. K. Solution and various other trade names, and has been used very largely in the dairy industry in sterilizing bottles. It is a very efficacious substance and can be carried around in five gallon bottles. It runs from about three to four per cent available chlorine.

I presume most of you are familiar with that material. It occurs to me that, in the event that one did not have a portable chlorinator, it would be possible to take a sufficient quantity of this material to the point where the new mains were being laid and apply it in the main with sufficient water to carry it through, and in that way effect sterilization. Your orthotoluidin test would be just as valuable with that material as it would with liquid chlorine. It might be that for a small job you could get it much more cheaply than purchasing a chlorinator. That material does not cost very much to make, but because of the fact that it is sold under a trade name it is very much more expensive than liquid chlorine. That is a condition that possibly could be remedied by concerted action on the part of the waterworks men. In other words, if it merely could be used around the water works plants and in the mains, and one thing and another, it might be possible to bring enough pressure to bear on the manufacturers to get it at a reasonable price. It does not have to be chemically pure. The main thing we want in it is chlorine.

There are a number of other uses to which that material can be put, that I might just mention in a general way. It so happened that I was made a present of some twenty-five or thirty gallons of the solution, and I find it a very nice thing to have around the waterworks plant because, in case of any little local infection of any of your units it is very easy to treat that particular unit or piece of pipe, or whatever it may be, basin or reservoir, with chlorine in this manner, where the use of a chlorinator would either mean the purchase of new equipment or the transferring of some stationary equipment to various points around the waterworks plant or away from the waterworks plant, which is not a practicable thing to do.

We had some filters that were infected with organisms which were giving us rather too high a bacterial count, and we used some of this material in the filter for the sterilization of the filter proper, that is, the sand and underdrains. It can be applied for that purpose. It is already strongly alkaline and can be used in conjunction with caustic soda for the removal of accumulated alum residue, which I presume you all have on your filters from time to time. In the case of an infected filter, the entire filter can very readily be sterilized by a sufficient quantity of this stuff and drawing it down through the filtered waste valve until your whole filter is thoroughly impregnated with this solution which will result in the sterilization, and if used in conjunction with caustic soda will mean the removal of accumulated alum sludge from the upper layers of the sand and the surface of the sand.

I just offer that as a suggestion, more particularly in connection with the sterilization of small water mains. I presume on a very large job, where a great deal of pipe is being made, it might pay to have a portable chlorinator. It certainly would be a much better way to effect sterilization if you could afford to buy the chlorinator. However, this solution will accomplish the same result on a small scale.

George F. Catlett:[8] Quite recently Asheville had occasion to sterilize some mains and some filters. We have not had any difficulty doing it simply with chlorine. We started an emergency filter plant up on the North Fork shed at Asheville, and it was very important, for various reasons, that we should get no B. coli in the laboratory test. Of course, the new mains will show B. coli and it really has not much significance. The objection to it is that it obscures the laboratory findings and entirely vitiates the value of the laboratory test.

We had to be careful, therefore, in starting up these emergency plants, to see that the mains and the pump wells and boxes should be thoroughly sterilized. They accomplished that on this North Fork installation by running a six-inch line over to the gravity main which comes down from the North Fork shed. We had that sterilized. We started the filters up and got water into the pump boxes, using a steam-fire pump. We started that pump going through the six-

[8] Sanitary Engineer, State Board of Health, Raleigh, N. C.

inch line and let the water go out through a ball valve. We simply took the tank of chlorine, put a piece of rubber tubing on it and put it down into the pump well close to the suction, and ran that. We got a very strong orthotoluidin reaction there. Then we had a man who continued running that chlorine just from the tank, until he smelled chlorine at the blow off. We then shut the pump down and let that water stay in the main for ten minutes and then started up in a normal way.

In the case of the Asheville Lake installation, they had an improvised filter. It had just been constructed of wood and filled up with stone and sand. There is no question, but that you have got a B. coli reaction from that filter bed. It had no significance except that it would obscure the laboratory control of the water and would give positive tests in the mains entirely from that cause, and we would not have known whether other causes entered into it at all. We used the same method there. We took the tank of chlorine up and the rubber hose, and cracked the valve and let it drop into the rubber tube all over the filter bed until we got a very strong orthotoluidin reaction. Then we sterilized the pump well and also the pipe line in the same way. It seems to me that in all filter plants, all filter supplies in the State that have chlorine available, a simple tank of liquid chlorine can be utilized in every case to sterilize the main or any part of the plant. Of course, in a deep well plant where they are not using chlorine sterilization, it is necessary to provide other means. But it seems to me that the tank of liquid chlorine can be utilized for sterilizing mains and be also used as Mr. Norcom described in the chlorine solution. We have done that at Asheville very successfully. We had no difficulty in putting it in, and the results were perfect. We got sterile plates.

Burt B. Hodgman:[9] Recently, in Newark, a 20-inch main was laid, the ditch was flooded overnight and they got two or three inches of clay mud in the pipe. They sterilized the pipe after they had finished the laying, and flushed it, but they still got B. coli after a test two or three weeks later.

Mr. Legree: I just had an experience along this same line in a little town in South Carolina. The water showed up contaminated.

[9] Civil Engineer, New York, N. Y.

I thoroughly investigated the water supply. It was a deep well. We tested the water at the pump, in the reservoir and in the standpipe. We found good water. We tested it down-town at different points and found the water contaminated. I filled up the tank and drained the reservoir, left the tank full, thoroughly cleaned out the reservoir, put in a solution of hypochlorite and filled up the reservoir. Then I drained the main and the tank and filled the system with this water. We found in the main, in some cases, mud, etc. We treated this water for two days and the bacterial tests showed up all right. Since then they have had no trouble at all. Unquestionably, the contamination was due to laying the new water main and not taking the necessary precautions after the system was built to disinfect it.

George D. Norcom:[7] It has been my opinion that you cannot hope for any penetration into several inches of mud that may be at the bottom of the pipe. I do not think that the chlorine could possibly penetrate that deeply so as to do away with all chances of contamination. It would seem, in Mr. Hodgman's case, as if some other method of cleaning that main would have to be resorted to.

George F. Catlett:[8] In connection with the sterilization of the main, the case I just cited was one in which we had complete supervision, and the North Fork shed was far enough away so that we had no fear of putting in a little bit excess chlorine—we felt it would disappear after it passed through that long line. In the second case we blew off the chlorine.

Some time ago we had a case of new filter plant, and as usual, we increased the chlorine, sterilized the main—and nothing was said about it to the public. The Coca-Cola Bottling Works in town bottled a lot of goods, using this heavily chlorinated water, and sold it to the surrounding towns, and they came back very indignant and were going to sue the town. They said that they not only had to destroy those goods, but they had had their trade ruined and it put them at a disadvantage with their competitors.

I think there is a lesson we can get from that incident, that it is important to handle sterilization intelligently. It you can not blow the water off, waste the water that you use for sterilization. The people should be advised of it before it is done.

In one case the people were advised, and not only that, but they did not want the people to drink the water at all, but to boil it. And

one of the objects in putting the chlorine in was to develop a taste so objectionable that they would not drink it.

In another case, they had a pollution and they decided to sterilize their mains. So they used the newspapers and warned the people that at a certain time they would put this chlorine in there and it would have a bad taste and it would be entirely harmless, though slightly disagreeable. That went by without any difficulty.

But I think it is important, when you adopt sterilization methods to provide either for wasting that water or else advising the people that it must be done, and give them the entire facts about it.

J. E. Gibson:[10] Before you close the discussion I would like to ask if any of these men have chlorinated new mains and have had any phenol taste, due to this sterilization.

George F. Catlett:[3] We usually have a slight phenol taste in the mains, anyway, although we have no scientific facts and figures before and after. But the general observation is that there is probably a little of that taste.

[10] Manager and Engineer, Water Department, Charleston, S. C.

STERILIZATION WITH FRESHLY PREPARED HYPOCHLORITE[1]

By H. A. Lilly[2]

The attached sketch shows a device used for combining chlorine with an alkali, and feeding the resulting hypochlorite into water for sterilization purposes. The chlorine passes out of the cylinder through a copper tube, enters the bottom of the glass chlorinating chamber through a glass tube, and bubbles through the solution of alkali as the alkali passes in at the top of the chamber and out at the bottom. When the alkali is in the form of a carbonate, hypochlorite is formed in accordance with reaction 1.

$$R_2CO_3 + Cl_2 = RCl + ROCl + CO_2 \tag{1}$$

When an alkaline hydrate is substituted for the carbonate, the chlorine combines as shown in reaction 2.

$$2ROH + Cl_2 = RCl + ROCl + H_2O \tag{2}$$

In either case the fresh hypochlorite solution passes out of the chlorinating chamber into the filter effluent and decomposes in accordance with reaction 3. The nascent oxygen destroys the bacterial life in the water.

$$ROCl = RCl + O \tag{3}$$

The above method of sterilization has been in use at the Badin filter plant since May 28, 1925. When the filters are started the needle-valve is opened wide enough to give a slight excess dosage of chlorine, the ortho-tolidine test is applied and the dosage cut down to 0.3 part per million which, in the case of Badin water, gives a satisfactory sterilization.

The number of pounds of chlorine added per twenty-four hours is

[1] Presented before the North Carolina Section meeting, September 15, 1925.

[2] Chemist, Tallassee Power Co., Badin, N. C.

determined by weighing the cylinder at the beginning and the end of the day.

The quantity of alkali is governed by adjusting the valve on the effluent pipe of the chlorinating chamber. Enough alkali is added to raise the pH of the filter effluent from 6.4 to 7.0.

The normal variation of bacteria per cubic centimeter in the filter effluent, previous to the addition of hypochlorite, is from 5 to 50; after disinfection it is from 0 to 2. Daily tests on 10 cc. portions of

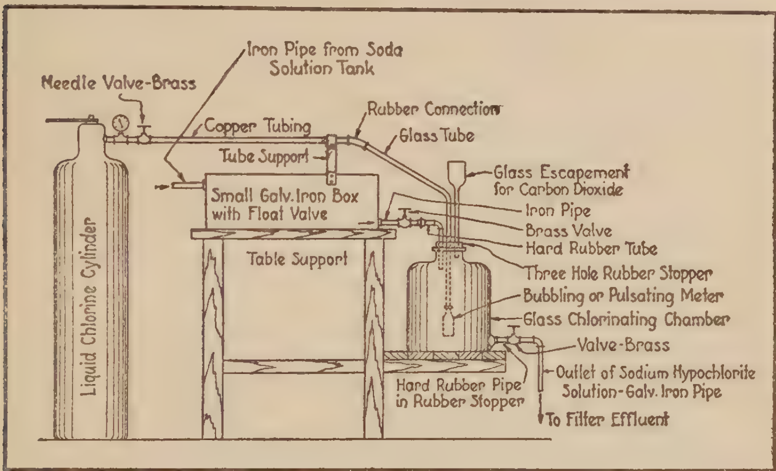


FIG. 1

water treated by the above outlined process have failed to reveal the presence of colon bacteria since the process was put into use on May 28, 1925.

The entire equipment including scales cost approximately $50.00. The equipment is easy to assemble, install, and operate. Any broken parts may be replaced at small expense, and no expert has to be called for repair work. In closing I would like to state that I think this process of sterilization is most economical and efficient.

EFFECT OF IMPOUNDING RESERVOIR ON WATER AT GREENSBORO, N. C.[1]

By C. W. Smedberg[2]

Prior to the construction of the impounding reservoir at Greensboro, dependence was placed on the combined flow of Horsepen and Reedy Fork Creeks for the city water supply. The water being drawn direct from the stream and pumped to a storage reservoir of 20,000,000 gallons capacity from which the filtration plant is supplied by gravity The storage available in this reservoir at present rate of consumption is equivalent to a 5 days supply.

The fluctuations in the stream flow and the mounting consumption made pertinent the construction of an impounding reservoir. The reservoir dam is located at a point directly below the juncture of the two streams and impounds the water along each creek for a distance of approximately $1\frac{1}{2}$ miles, the water from the new reservoir being pumped to the auxiliary reservoir as heretofore. The capacity of the impounding reservoir is approximately 1,000,000,000 gallons or equivalent to 250 days supply, and together with that of the auxiliary reservoir affords a storage equivalent to 255 days on the present rate of 4 million gallons per day consumption.

Clearing operations within and along the margin of the reservoir delayed placing the full reservoir capacity into use until this spring and effects which the impounding of the water may have on its quality and filtration plant operation, have only partially been experienced at the present time, a much too short a period to arrive at definite statements or conclusions. Certain changes have taken place and to such extent as to be especially noticeable.

Both of the streams feeding the reservoir being exceedingly flashy by nature and originating on a water shed composed of clayey soils and rugged topography, a wide and sudden variation in the amount of sediment carried and degree of turbidity existed, with corresponding variation of slightly less degree of the water delivered to the filtration plant. The large amount of storage now available has

[1] Presented before the North Carolina Section meeting, September 16, 1925.

[2] Water Department, Greensboro, N. C.

resulted in a water of more uniform character. Formerly turbidities of 400 to 500 p.p.m. were not unusual in contrast to the present turbidities of rarely more than 30 p.p.m. and during the greater portion of the time 10 p.p.m. and less.

Color increases have been noted, the maximum being 20 p.p.m. whereas formerly it rarely reached 10 p.p.m. The color increase has been anticipated as the site was not stripped of vegetation or top soil. An increase over the amount of color already observed probably will occur, but eventually will be reduced as silting occurs.

A decrease in the H-ion concentration of the water has been noted, necessitating an increased dose of alum to secure optimum coagulation conditions. The average pH prior to the use of the impounding reservoir was 6.8, whereas at the present time the average is 7.0, with a maximum observed of 7.6. No change in the concentration for optimum coagulation of 6.4 has been observed.

Microscopic organisms and algae already have been produced in sufficient number in the short time the reservoir has been in use to indicate our most troublesome problem in the future. Microscopic examination shows a continual increase in number, indicated also by the reduction of the filter runs by 50 per cent over that of the same period last year and the heavy growths within the basins. At times, a distinct fishy odor is noticeable around the basins and on washing a filter, but as yet this has not been sufficient to impart odor or taste to the water. Present indications point to the necessity of proper treatment to hold down microörganisms during the coming year to avoid tastes, odors, and decreased plant efficiency.

THE CALIFORNIA RAILROAD COMMISSION AND THE WATER WORKS MAN[1]

By M. R. Mackall[2]

The relation of the Railroad Commission to the water works man, if he is operating a public utility, is like the poor, it is apparently bobbing up at every turn. The Commission authorizes the beginning of the utility, prescribes its system of accounting, fixes the rates it may charge, supervises its financial operations, such as stock and bond issues, and may fix the value of the properties for condemnation purposes, upon request. In addition, no sale of a public utility can be legally made without authority of the Commission. In fact, one cannot even discontinue or abandon plant and service without the sanction of the Commission.

In spite of this almost complete authority of the Commission its powers are not in any way abused. Too much regulation may be a detriment. If any one thing may be sought out as primarily responsible for the uniform success of public utility regulation by the California Railroad Commission, I believe it is because of the strict adherence to the policy of placing full responsibility upon the utilities and giving them all free rein in individual initiative, operation and management, interfering only when conditions so demand. I do not mean to convey the impression that any responsibility is to be shirked by the Commission through this policy, for such is not the fact. The Railroad Commission has in at least one instance gone to the extent of directing the managing head of one of the largest utilities in the state to leave his San Francisco office and take up his residence in another city until such time as the service conditions then existing in that city were raised to a reasonable standard.

The regulation of water utilities is but one of the many duties placed upon the shoulders of the Railroad Commission. This Commission now has jurisdiction over the rates, rules and regulations of steam and electric railroads, street railways, grade crossings, accidents involving common carriers, safety regulations, wharves and

[1] Presented before the California Section meeting, October 16, 1925.

[2] Hydraulic Engineer, California Railroad Commission, Sacramento, Calif.

warehouses, inland water carriers, oil pipe lines, gas, electric, water, telephone and steam-heating utilities, supervision over the erection of dams by power and water utilities, and also automobile stage and trucking companies, passenger and automobile ferries, and even airplane transportation.

Although somewhat foreign to this subject it is perhaps necessary to a complete understanding of the Commission's activities to see where its powers emanate. The United States Supreme Court in the case of Munn vs. Illinois held that a state had the right to regulate a business affecting the public interest, in this case a grain elevator business. In a later case involving the German Alliance Assurance Company the same court held that this right of the state could not be defeated by doing business under private contracts such as insurance policies, and set up the principle that the states could even regulate the terms of such private contracts.

Heretofore the powers of fixing rates for concerns selling water, gas, electricity, etc., were vested in the county boards and city councils. Valuations were determined in the civil courts. With the general increase in growth of the cities and with the attendant expansion of utilities to large corporations, in many instances covering the entire state, the fixing of rates and the regulation of business became too great a burden upon the resources of the cities and counties and the courts. Furthermore, matters of financing large enterprises demanded on the part of the investing public a stabilizing factor in the form of some uniform and definite policy based upon practical and scientific methods of valuation and rate fixing, removed from the uncertainties resulting from changes in local political administrations. The consuming public demanded that their rights be protected and that each member of the public have some means whereby he could obtain redress in case of necessity without great financial outlay.

The State Constitution was amended in 1911 authorizing the state to delegate to the Railroad Commission the regulatory powers therefore enjoyed by the cities and counties, except that it was not until the year 1914 that the Commission was given sole authority over matters involving the regulation of rates. The authority granted by the Constitution was enacted into law by the State Legislature in the Public Utilities Act.

At the outset it should be explained that the Railroad Commission has no powers or jurisdiction to any extent whatsoever over

water systems owned and operated by municipalities, counties or groups of towns and cities, or legally constituted water or fire districts, or over mutual water companies, nor has the Commission any jurisdiction over irrigation districts. In this connection I might say that I frequently have inquiries from municipally-owned water systems asking if the Commission can acquire jurisdiction over a city water system, if water is served outside the city limits. The answer is that it can not. This specific point was definitely established by our State Supreme Court in a case involving the City of Pasadena.

It may be well to point out at this time that the powers and rights and decisions of the Commission must comply strictly with not only the Public Utilities Act, but also with the laws of the land, and the State and Federal Constitutions. Every order issued by the Commission is subject to the right of review before the Supreme Court of the State and then to the Supreme Court of the United States at the instigation of any party to the proceeding.

As affecting water and irrigation systems, the authority of the Railroad Commission is principally regulatory. It has power upon request to determine value for condemnation purposes, to fix rates, to establish reasonable rules and regulations governing the service of water, to prevent unfair discrimination, to prevent rebates and the granting of special privileges to favored consumers—a thing which rarely happens in modern times, but was once given wide-spread publicity by early practice in railroad operation.

The power of the Commission to regulate rates can not be defeated by private contracts between the utility and a consumer when the commodity has once been dedicated to the public use. In the case of such contracts involving water service the Commission has uniformly disregarded them when such contracts created an unfair discrimination against other consumers. Based upon a decision of the California Supreme Court, the Commission disregarded a contract in which the Spring Valley Water Company had agreed to supply the Newark Station of the Southern Pacific with free water service in consideration for the right to cross the Southern Pacific tracks with a pipe line. The water company was directed to charge the regular rate schedule for such service, upon the theory that such an unlimited contract amounted to an unfair discrimination against the other consumers.

There is a limit, however, to this doctrine. Although the doctrine

of the German Alliance Insurance case is to the effect that private contracts can not alter the right of a state to regulate the sale of a commodity or business affecting the public interest, nevertheless the clash between water rights in this state influenced the California Supreme Court, which has limited this power of the Commission, to apply only when the water has been dedicated to the public use prior to the contracts. This matter was so decided in a case where this commission attempted to disregard certain contracts in the fixing of rates. Thus the question of whether the Commission has the power to disregard and supersede the rates set out in a private contract is simplified by making it necessary to determine only whether the water was dedicated to the public prior to the making of the contract. While this is apparently a simple matter, the fact remains that in practically every such determination the matter never stops until it arrives in the Supreme Court in Washington.

The question of whether a contract whose rates have been superseded by a change in rates legally made by the Commission is made unenforcible as to the other terms contained therein, is now before the Supreme Court of the United States for argument. The California Supreme Court held that the other terms remain in effect. Incidentally, this is a case involving an irrigation company in Butte and Sutter Counties.

Before a private company or individual can operate a water system a franchise must be procured from the city or county in which it proposes to render service, after which an application must be made to the Commission for authority to legally operate. This can be granted only after a public hearing, and is called a certificate of public convenience and necessity, immediately after receiving which the real trouble commences.

A utility may file an application at any time with the Commission for an increase in rates, which can only be granted by formal order after the holding of a hearing open to the public. A request by a utility for a reduction in rates may be granted informally by the Commission without a public hearing, provided no discrimination results. As many of you have already suspected, this removal of complications has not resulted in an epidemic of requests for lower rates.

The time required to render a final decision in a rate proceeding varies from one month to one year from date of filing, depending upon the size of the plant and the amount of work pending before the Hydraulic Division for investigation. It should be remembered that

all affairs and complaints involving every public utility water system in the state are conducted by a department composed of but seven engineers. This is quite a task when it is considered that there are 431 public utility water companies in this state.

This paper cannot cover in any but the most cursory manner the great question of rate fixing and public utility valuation. The matter is highly complicated and involved and has an almost unending variety of problems peculiar to each individual case, many of them not as yet definitely settled by law or even practice.

When application is made by a utility for rate adjustment a complete inventory of the entire properties should be submitted at the same time. If the size of the plant and the financial conditions of the company warrant, this inventory as well as an appraisement of the properties should be prepared under the direction of a competent engineer familiar with valuation matters. The engineers from the Commission after checking the inventory prepare a report giving an independent valuation of the properties and containing an analysis of the costs of maintenance and operation during the past for the purpose of determining the reasonable and proper expenses for the future. The report of the engineers of the Commission must be substantiated by the evidence and subject to cross-examination exactly as any other matters presented to the Commission.

The Commission has generally in the past adhered to the principle that valuations for rate fixing purposes should be based upon the reasonable historical or original cost of the investment in the physical properties which are being devoted to the public use at the time of the proceeding. Lands and rights-of-way, however, are appraised at the present market value. Consideration is also given by the Commission to the present value of the plant as determined by the reproduction cost of the properties less accrued depreciation. It is perhaps advisable, therefore, especially from the standpoint of future financing, for any utility contemplating an application for an increase in rates before the Commission, to present both an estimate of the value of the properties based upon the historial or original cost, and upon the reproduction cost theory less accrued depreciation.

In arriving at a fair value for rate fixing purposes the Commission will exclude non-operative lands, structures and equipment. Intangible values such as going concern, development costs, working capital and water rights are also elements which must be given proper consideration. Thereafter, if conditions so warrant, a schedule of rates

is designed to yield the utility a fair return upon its investment over and above the reasonable cost of operation, maintenance and depreciation. While a fair return under normal conditions is taken by this Railroad Commission at approximately 8 per cent in ordinary utility practice, yet the Supreme Court of the United States has frequently held that a return of 6 per cent may at times properly be held a fair return and will not amount to a confiscation of the properties of the company without due process of the law.

There are of course a great many exceptions to the granting of a full return upon the rate base as found. For instance, it frequently happens that in order to produce a fair return upon the investment a rate would be required which would be so high as to be prohibitive. Unfortunately this situation is by no means rare in this state, especially so far as water utilities are concerned. We have a great number of water companies which have been primarily installed by real estate concerns for the purpose of aiding in the sale of lots. When the real estate operations on many of these subdivisions have arrived at the point where they are no longer lucrative, the operator, if he cannot find a victim to relieve him of his public utility burdens, is required to continue the operation of his plant until such time as the territory develops to the extent where a fair return can be realized through a reasonable rate. There are many water systems starting out which are still in a development state, and in justice to the consumers served by them are not yet entitled to a full return upon the capital invested. There are a great number of irrigation and domestic water concerns which have been the outgrowth of the old mining ditch systems of the early days where the territory served, formerly supporting flourishing communities, is reduced to the extent that the company is unable to meet bare operating costs.

The right of the Commission to fix a rate under these circumstances at a figure less than that which would give a full return upon investment, was recently questioned by one of the power companies in the southern part of the state, which took exception to the ruling of the Commission that the territory served was in a state of development. This matter was taken into the federal courts in California, and while dismissed, resulting in a victory to that extent by the Commission, yet nevertheless was dismissed upon a technicality and the real point at issue has accordingly not been settled by the United States Supreme Court.

A decision by the courts precluding any regulatory body from using

its discretionary power in the fixing of rates would be a calamity and a death blow to public utility regulation. Any system of regulation, whether by courts or administrative bodies, which disregards the great economic principle that there is a limit beyond which the value of the service rendered can not go, is doomed to failure. Although the position of this company was primarily that of questioning certain findings of the Commission to the extent that the rate fixed was actually all that the traffic would bear, and while this company perhaps did not insist that the Commission should be deprived of all discretion in matters of rate fixing, yet nevertheless the principle involved was unescapable, and if carried to its logical conclusion would result in the regulation of rates purely by mathematical formula.

The Commission has, in the designing of rate schedules, tried various methods of determining the charges to be paid thereunder. For a water company the fundamental need is to have a proper amount of money returned to it each year by way of revenues. It is, at least theoretically, only incidentally interested in the manner in which these rates are spread among its consumers. Although the Commission has tried scientifically-designed rate schedules wherein it was necessary to depart from time-honored practice, yet such changes have created such storms of protest as to make the practical application of such rates hardly worth while. The Commission has therefore quite uniformly adhered to the simplest and most readily understood forms of rate structures.

The Commission experienced a considerable handicap in rate fixing by that custom of the early days in which the cities in granting a franchise to a water company would require that all water served to the city itself, including fire service, should be free, Investigations by the California Railroad Commission, as well as the investigations conducted by other regulatory bodies, have determined that the actual cost of investment for the delivery of water for adequate fire fighting purposes runs from 25 to 75 per cent of the entire plant investment. The cost of maintenance and operation of the system is increased proportionately. The difficulty of course lies in the fact that in order to deliver a large volume of water in a short period of time, a greater capacity of distribution and transmission mains, as well as storage and standby equipment, is required than would be necessary for normal domestic service. This Commission at an early stage adopted the principle that free municipal service was

unfair and discriminatory and should be abolished, and proceeded to fix rates to be charged municipalities for fire service, sewer flushing, and for other municipal purposes, upon the theory that the entire cost of operating and maintaining the additional investment required for these municipal functions should not be placed upon the shoulders of the regular consumers, but should be paid for by the property owners who directly benefit thereby. While this principle was unpopular among city officials who were more vitally interested in a lower tax rate than in equalizing the consumers' burden, nevertheless its fairness and reasonableness soon commended itself even to the municipal authorities, and the practice is now firmly established.

The public utility water companies perhaps come in contact with the Hydraulic Division of the Railroad Commission more often through our informal complaint department. This department was organized by the Commission as a result of its general policy to promote a better understanding between company and its consumers and to promote a spirit of coöperation in the general relations of utilities with their customers. While in general the Commission must make a formal order before it can legally demand and require compliance with its suggestions and instructions, yet there are so many matters that can be as readily solved informally without the delay and expense attendant upon formal proceedings, that the commission endeavors whenever possible to settle all complaints informally by correspondence between the parties or by personal investigation when the facts demand it.

During the last fiscal year the Commission settled informally 784 complaints as compared with the rendering of decisions during the same period in 179 formal proceedings requiring public hearings. The informal complaint department has developed into a branch of great importance not only as to economy in saving time and money for utility and consumer, but also by speeding up of final settlement of complaints which otherwise would require formal action and decision by the Commission.

Of the complaints filed with the Commission approximately 40 per cent involve disputed bills, 30 per cent inadequate or interrupted service, 20 per cent service installations and extensions of existing mains for service. The remaining 10 per cent cover complaints against the reasonableness of the rates or the classification charged, refunds under deposits, unjust rules and regulations, and the multitude of other causes which only a water works man can believe

possible, including many that he honestly believes impossible as well.

It is a pleasure to inform you that the complaints coming to the Commission are changing very definitely in character. There is a decided lessening from year to year in the number of trivial complaints coming to the attention of the Commission. Unfortunately for those of us charged with the duty of untangling these usually very difficult problems, only the more involved and complicated matters are now being referred to the Commission for settlement. This simply means that the later companies have most generally adopted the broadminded attitude that good business demands every effort to meet the public fairly and honestly, and that the establishment of a good feeling with the customer through an earnest effort to settle disputes and complaints pays more than one hundred per cent upon the investment, in spite of the monopolistic nature of the business. As a matter of fact this is well illustrated by the fact that the Commission will receive more complaints against some small utility serving a community of perhaps two to five thousand in population than it will receive against the companies serving cities over half a million in population. In most cases this is due to the personal element rather than to service matters. The reason of course is obvious; the larger the utility, the greater is the realization that special efforts devoted to its public relations result in removing friction and reducing operating costs. The larger utilities have all found that special departments organized for the handling of this phase of business is an absolute necessity.

One of the greatest causes of difficulty experienced by the Commission in dealing with complaints is that involving the class of water systems installed by real estate operators to make possible the sale of lots. It is almost the universal practice for these operators to use the cheapest type of materials, adopting quite novel theories of construction, with inadequate sized pipe and usually with little or no storage facilities. Irrespective of whether the system is destined to serve ten people or ten thousand, apparently there is some law, written or unwritten, handed down from father to son, which makes it a felony for any real estate operator to install in a subdivision any pipe larger than two inches or to provide storage facilities more complicated than a 5000 gallon tank, set upon the ground at the lowest point in elevation on the tract. There may of course be some exceptions to this. The difficulty arises when the cream of the lots is

disposed of and the water system becomes a burden. Usually the water supply is inadequate, the service is almost unbearable, and the rates, already insufficient to pay a fair return upon the investment, cannot be increased, for in most cases the charges are already all that the traffic will bear. The consumers of a public utility are entitled to continuous and reasonable service at a just price. The utility is entitled to a rate which will yield a fair return upon its investment. The Commission cannot force any utility to operate its water system at a loss; to do so violates the 14th amendment to the Federal Constitution, which forbids confiscation of private property without due process of the law. This is a problem that is not only not rare, but is a common occurrence.

The solution of this particular problem is apparent to me in only one way, and that is to require the proper type of installation at the outset. Under existing laws this cannot be done. The counties and cities may grant a franchise to a company to construct a water system in the public highways, after which the company applies to the Commission for a public utility certificate. The cities and counties have no authority to demand certain standards of installation and service facilities. As a matter of fact the entire necessity for the procurement of a franchise is easily avoided by installing the water system before the subdivision is accepted by the authorities and the streets dedicated to the public use. As to the withholding of a certificate to operate by the Commission for improper standards of instalation, no such authority is apparent in the Public Utilities Act. The Commission itself is necessarily the greatest offender in this regard, for a majority of those applying for certificates for the operation of a water system have already been supplying a considerable number of consumers, in some instances for several years. To deny the certificate under these circumstances means that the existing consumers in 99 cases out of a hundred will be left entirely without water service from any source whatsoever.

Matters of grave concern to the Commission as well as the water companies are those arising out of demands for service from an existing utility which require the extension of mains or other facilities. This is most acute in cases involving real estate subdivisions. In cases of ordinary extensions to individual consumers the Commission generally requires a water system to extend its mains at its own expense 150 feet for each bona fide consumer, the excess cost to be paid by the applicant, which is to be refunded to him in various ways

when new consumers come on the line within a certain definite time limit. The fairest method of extension would perhaps be to expend a certain definite amount of money for each consumer. However, the varying conditions and the complications arising from keeping track of the costs, make this impractical. The 150-foot rule is the most simple and satisfactory in the end. The time limit for refunds, by the way, is of great importance. A period not to exceed ten years appears to be fair to all parties. In one instance I recall a utility entered into a very elaborate agreement some twelve years ago in which the subdivider put up the money and the water company installed the mains in a large tract, with the provision that when a certain number of consumers were obtained on the tract the entire deposit would be returned in one lump sum. No time limit was fixed. The status of this matter at present is that the company was forced to spend a large sum of money to increase its facilities to serve the tract, which was very slow to develop. At some time in the future the company will be forced to pay a large sum of money in one payment for a system which will need entire replacement within a few years.

The Commission's attitude on extensions to serve completely newly subdivided tracts of land which are to be placed upon the market, is that community growth and expansion should not be throttled by a utility which by law has a monopoly on the service of water to that particular community and is therefore under the obligation to serve all members of the public without discrimination. However, for the protection of the existing consumers the utility should not endanger its facilities or its financial structure by assuming a part of the risk in an independent and speculative business venture. If the tract is a failure, the investment, if made by the utility, may very properly be disallowed to the extent of this failure, in a rate fixing proceeding before the Commission. There are several water systems in the state where extensions covering large tracts have been made as the result of misguided enthusiasm, on which years later there were still more than one thousand feet of distribution mains to each consumer. One hundred feet is normal. Obviously such ventures do not pay dividends, especially when the time for replacement arrives. The reasonable thing to do then, is to protect the present consumers of the water company by requiring the applicant for this type of extension to deposit with the utility the estimated reasonable cost of the entire installation, to be refunded over a definite period from a

percentage of revenues received from the extension when the development of the tract so warrants it.

The difficulties which arise here are mainly over the size of the mains and the type of materials which should be paid for by the applicant. The size and materials should conform to the general practice of the utility as modified by any peculiar local conditions existing on the new tract. It would be unfair to require an applicant to pay for a twelve inch main to be used for other parts of the system, as it would be equally unfair to charge for eight inch pipe where under similar conditions the practice has been for the company to use four inch and six inch mains. It would be equally unfair to require payment for the installation of cast iron pipe where the remainder of the system is of standard screw or riveted steel pipe, although in the matter of materials this may be qualified in certain cases where there is immediate danger of the territory served by the utility being taken over by a municipally owned water system having certain definite standards of water works construction.

The question has frequently been asked by water companies operating on flat rate schedules whether formal request is necessary for the installation of water meters. In reply to this it should be stated that no authority is required from the Commission to install meters. The complications however arise when the attempt is made to charge for the measured service. This may be done if the company has already a rate for measured service, but where there is no such rate the company is practically precluded from charging more than the existing flat rate, for the reason that to do so would amount to an increase in the established rates. This cannot be done without authority from the Commission. Where no meter rate exists, therefore, it will be necessary to apply to the Commission for the fixing of a rate for metered service.

The Commission has been severely criticized in certain communities for its attitude in recommending that all water should preferably be sold through measuring devices, except in cases of very small utilities and where there happens to be an unlimited supply of gravity water. This opposition is of course a relic of the early days when most people had their own private water supply and were free to use the water as they saw fit. One of the greatest obstacles to water works operation is this same general feeling that water should cost but little to deliver to the home. As a matter of fact the delivery of adequate water service in this state is increasing in seriousness and

complexities each year, particularly in the water supplies of all of our larger cities. When one considers that facilities must be provided to give each individual living anywhere in the community the privilege of going to the faucets in his home at any hour of the day or night and finding available an unlimited supply of fresh, pure water, the value of that service is the vital factor, and the cost to produce and maintain that service is now a considerable burden. Anything which will reduce this cost is a desirable thing to the consumer as well as the utility. Selling water upon the basis of payment for the amount used reduces this cost by reducing waste, reducing main and storage capacity, and by reducing pumping expenses where pumping must be resorted to. Above all it puts the operations upon a definite and business basis. Curiously enough there is practically never any objection before the Commission to the metering of electricity or gas service, yet there is frequently very bitter opposition against metering water service. However, once the measured system is installed, the prejudice usually disappears, especially when all services have been metered.

The Commission has frequently before it complaints that partial metering results in a discrimination against metered consumers in favor of flat rate users who have no limit placed upon the amount of water that can be used for a given monthly charge. In this regard it should be stated that this practice is a discrimination and one that in certain instances can be a very unfair one. However, no rate schedule can be devised which will be free from discrimination; but unless this apparent discrimination is unfair and unreasonable, for all practical purposes it may be ignored.

When meters are installed upon those consumers using large volumes of water or requiring intermittent supply or upon those who indulge in wasteful practices, there is to all practical purposes no unfair discrimination against them if they pay for all the water actually used at a reasonable rate fairly comparable with the charges for flat rate service. The remaining difficulty in discrimination, resulting from a mixed flat and metered service, is to use good judgment in metering consumers so that of two neighbors of the same class one will not be needlessly antagonized by being placed upon a metered basis, while the other remains upon the flat rate charge for no logical reason. If this must be done, please settle the war yourself and do not refer it to the Commission.

An interesting recent development in the arts has resulted in

bringing additional joy into the care-free life of the water works operator. I refer to the battery type of underground lawn sprinkler designed to relieve the householder of all excessive physical and mental fatigue. From an operating standpoint, this system demands a good pressure and sufficient capacity to serve a large volume of water for a short period only, and therefore usually requires replacement of the former service with at least a two-inch connection, including the meter.

The consumption of water is not as great as the size of the service connection would normally warrant, and to help matters out the sprinkling is indulged in only during the summer season. An epidemic of these sprinkling systems in one or two blocks is liable to spell disaster for the usefulness of the street main formerly adequate. The only remedy for this situation is to readjust the monthly minimum charge for the size of the connections used for this service so that revenues will be produced commensurate with the cost of the facilities necessary to render this service. Another method would be to fix a special minimum rate for services where this type of sprinkling device is used.

The Hydraulic Division is now endeavoring to work out a new system of general rules and regulations governing the relations of general service matters with the water consumers. Our present rules and regulations are general in character, but since their adoption conditions have changed in many instances, so that revision will undoubtedly prove beneficial. In this regard the thought occurred to me that information on the similar practices of other utility commissions would be of great value, consequently letters were written to all such boards in the United States. The results were quite surprising. Although I have apologized for so many years over our own rules and regulations that I had almost begun to suspect they could stand considerable improvement, I discovered that only a handful of the other commissions had any themselves and most of them declined to accept any responsibility for their efforts. After looking them over I am frank to state that our own did not suffer any by comparison.

Seeing that I have carefully refrained from mentioning the Railroad Commission up to this point, I might as well state at this time that I believe the people of this state are particularly fortunate in having had appointed to the Commission very able and broadminded men who through unwavering fairness and through the constant

endeavor to solve their many diverse and complicated problems by the applicaton of sound common sense methods have created a regulatory board in this state which I am proud to say is generally conceded to be second to none among utility commissions in this country. The decisions of this Commission are given great weight as authorities and precedents throughout the entire United States. In view of the comparative newness of our western country this is indeed not only a compliment to our state and its institutions, but it is of course one of the reasons why regulation by this Commission, I sincerely believe, has been uniformly successful. Regulation to be a success and to survive must be sound, sincere and unbiased. Only when this is the case will the public, the utilities, and those members of the public who invest their money in the securities and stock of the utilities be satisfied.

My experience throughout the state with many water utilities has led me to believe that certain practices are sometimes overlooked by the operators which will prove of great benefit if adopted.

In the first place, meet your consumers more than half way and grant them the utmost consideration, even though they may be wrong. A man available to investigate promptly service and other similar complaints on the premises will more than repay the utility for the effort. The larger utilities have found that large dividends by way of good feeling and increased gratefulness are paid by having available a man who can advise the consumers tactfully as to certain of their service problems.

From an operating standpoint a simple and uncomplicated bookkeeping system that will reflect the financial status of the utility at any time desired without the aid of a corps of valuation engineers and expert accountants is a most valued adjunct to the business, and while neither difficult nor costly to maintain, is, I regret to say, all too rare among water companies.

Too many water utilities neglect the keeping of large scale service maps showing the tied-in locations of pipe lines, gates, hydrants and services. While this is a simple matter to keep up to date when once started, many a company has spent more money prospecting for gates and mains with the assistance of one of the oldest employees who thought it was laid about in line with some house, than would be required to keep up the records for several years.

Whenever the finances of a plant will warrant, the addition of a competent engineer to the organization will amply repay the utility.

The keeping of simple and clear cost account records of all repairs, replacements and new installations of all kinds will be of the utmost value for the purpose of estimating future extensions and improvements as well as throwing light on past experiences. Remember that to be of value cost records should be prepared by practical engineering methods and not from the mere book-keeping standpoint.

Where financial troubles are becoming apparent and where the majority of the water is delivered upon a measured basis, the annual tabulation of the water consumption of the consumers will throw very definite light upon changed service conditions, will show where the water goes, and will instantly indicate whether the use of water is such that existing rate classifications are no longer properly spread and are in need of modification or readjustment. As a matter of fact all rates fixed by the Commission are based upon a study and analysis of the water use.

The experience of the Railroad Commission has clearly demonstrated that without exception a utility in financial distress means dissatisfied and complaining consumers. Remember therefore that before conditions arrive at the breaking point the utility owes the duty to its consumers, as well as itself, to lay its difficulties before the Commission, which is not in any sense a board of inquisition, but on the contrary at all times has its entire facilities, legal, financial and engineering, at the disposal of the utilities as well as the public.

LIABILITY FOR WATER-BORNE DISEASE[1]

DECISIONS OF THE SUPREME COURT OF THE STATE OF WASHINGTON RELATING TO POLLUTED WATER FURNISHED BY THE CITY OF EVERETT

By Homer O. Blair[2]

The Supreme Court of the State of Washington has just rendered decisions in two cases confirming judgments of the Superior Court of Snohomish County for damages granted by juries for wrongful deaths of persons alleged to have died from typhoid fever contracted by drinking water furnished by the city of Everett. One of the cases is that of Victor Aronson, as Administrator of the Estate of Senobia Aronson, Deceased, v. The City of Everett, and the other one is Gertrude Mary Roscoe, as Executrix etc., v. The City of Everett. Both of the cases are based on similar facts and for this reason are reviewed together.

In the Aronson case the $6000 verdict was divided by the jury, $2000 to the surving husband, and $2000 to each of the children. The court ruled that the award was not excessive as the record showed that the husband has been deprived of the services of his wife for a period in excess of thirty years. In regard to the children the loss of the care and protection that they would have received from their age up to the age of majority was found by the jury to be worth $2000 each.

The record shows that, within a comparative short time during the summer of 1923, there were about eighty cases of typhoid fever and a number of deaths therefrom in the city, on account of which a number of claims or suits have been filed against the city.

The city of Everett was engaged in the business of supplying

[1] Prepared at the request of the Editor. Material obtained from the advance sheets of the Washington Decisions of the Supreme Court, published by the Law Digesting Company, Olympia, Washington. For further data on legal aspects of similar cases, see the Manual of Water Works Practice, Chapter I.—*Editor*.

[2] Consulting Engineer, Tacoma, Washington.

water for domestic and drinking purposes to the citizens for a consideration and during the month of July, 1923, the water became impure, unwholesome, polluted and dangerous to life and health. The complaint charged that the condition of the water was known to the defendant, its officers and agents who were charged with the duty of keeping and maintaining the water in a pure condition, or with the exercise of reasonable care and inspection would have known the condition of the water. It is charged that the impure water was furnished for a period of six weeks prior to August 14, 1923, and the drinking of this water caused the death by typhoid fever of the persons mentioned in the suits.

In these cases it was established that polluted water was permitted to pass into the city mains through a by-pass connection at the Eclipse Mill Company's plant. On April 11, 1923, a 6-inch main was laid to connect two laterals, and, when the connection was made it permitted free circulation of water to the city users in the district served, and also a better service to the Eclipse Mill Company. Prior to this time the company was connected with the city water system, although it had its own pumping system connected with the river. The testimony showed that the pollution of the city water came through the mains of the Eclipse Mill Company's plant, which was situated on the Snohomish river. The water taken by the mill company from the river was not fit for human consumption, and it was not intended that this water should flow into the city mains for use by the inhabitants of the city. There was a series of check valves which were intended to prevent this water getting into the city mains. However, there was a by-pass which allowed the water to go through the mains without going through the check valves that had been installed. There was a gate valve in the by-pass and it was supposed to be kept closed to prevent water from circulating from the mill through the city mains. In addition, the city mains generally carried a higher pressure than the mill company's mains. During the epidemic of typhoid fever in Everett during the summer of 1923 an investigation was made which finally resulted in finding the gate valve open, and that the pressure in the city mains, temporarily lowered by heavy use of water sprinkling, was permitting the polluted river water to enter the city mains, resulting in typhoid fever.

It was the contention of the city that, at the time the 6-inch main was connected up in April, 1923, the Eclipse Mill Company

had agreed to remove the by-pass, and that the new pipe line was put in for the convenience of the mill to secure a complete circulatory system throughout. There was no issue before the jury as to whether or not the work was done in a workmanlike manner. The question as to whether this connection was made at the request of the mill company, or that they paid a part of the cost or whether they had agreed to remove the by-pass or whether a part or all of the valves and pipe lines were upon the mill company's property, were not matters material to the issue. It was negligence for the by-pass to be left there when there was no need for it, especially with the gate valve open. The officers of the city did not seriously contend that this by-pass should not have been removed.

The city claimed that there was no evidence that Senobia Aronson drank any of the water. But her husband, who was plantiff in the action, testified that he was afflicted at the same time as his wife, and when asked "where did you get your water," answered, "city water."

There was evidence that the city never inspected the valve in the by-pass from the date of its installation of the new main on April 11, until the 25th day of July, 1923; that the city made no effort during that time to determine whether it was closed, or to determine if it had been removed by the mill company. The situation is not parallel here with those cases where the chance of pollution is small and incidental, as, for instance, where a city watershed covers a great deal of territory and constant policing would be required to prevent contamination. In this case the city permitted water to be taken from a point close to where city sewers emptied into a line which was physically connected with all the users in the district. Nothing but the closed gate valve could prevent the polluted water reaching the consumers. The ease with which the valve could be sealed or the by-pass removed, and the imminent danger to be apprehended by failure so to do, are strong factors in the question of the city's negligence. It thus became a question of fact for the jury to determine, in the light of all the evidence in the case, whether or not the city was negligent on leaving this by-pass with the gate valve; whether it was negligent in its failure to inspect at any time thereafter, and whether it was negligent for failure to ascertain and remedy the condition of the polluted water after notice had been given it.

Some contention is made that notices were given to the health

inspector, and that such notice should not be construed to be notice to the city as far as the water department was concerned. It seems to the Supreme Court that complaints made to the health department were at least some notice to the city, for the complaints were made to the particular officers of the city selected to handle matters relating to the public health, and who were qualified to determine the city's course of action. Indeed, it might well be said that the health officer would be far better qualified to act upon such information than an officer of the water department whose knowledge might be confined to the physical construction of the plant rather than to the matter of precautions necessary to be taken to secure immunity from pollution. But the question more clearly is whether, considering the necessary close relationship between the city health department and the purity of water furnished by the city to its users, it can be found that notice reached the responsible authorities of the water department. In any event, however, the evidence showed the polluted condition of the water for a sufficient length of time to make it a question for the jury as to constructive, if not actual, notice to the city.

The city insists that the complaint was drawn on the theory of an implied warranty, and argues strenuously that the city in furnishing water to its users does not guarantee its purity and wholesomeness. Reliance is had upon the following cases, Canavan v. Mechanicville, 229 N. Y. 473, 128 N. E. 882, 13 A. L. R. 1123, and Green v. Ashland Water Co., 101 Wis. 258, 77 N. W. 722, 70 Am. St. 911. While both cases hold that a city furnishing water to its inhabitants does not impliedly warrant that the same is pure and wholesome, yet both of these cases recognize that the failure to properly inspect the water so as to keep it free from contamination is negligence. There is ample authority that a city engaged in furnishing water, electricity or other kindred services to its inhabitants for a profit is liable for negligence the same as any private corporation engaged in the same business; that the city does not act in a governmental capacity, and that there is an implied warranty that the water is fit for human consumption. Hayes v. Torrington Water Co., 88 Conn. 394, 92 Atl. 406; Jones v. Mt. Holly Water Co., 87 N. J. Law 106, 93 Atl. 860; Hamilton v. Madison Water Co., 116 Me. 157, 100 Atl. 659, Ann Cas. 1918D 853. As to which rule should be adopted, it is not necessary for the higher court to determine in this action, since it is held that the complaint is based upon the ground of negligence and not on implied warranty.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

The Ogee Spillway Section Defended. JOEL D. JUSTIN. Eng. News Rec., **94**: 945, June 4, 1925. Discussion of A. F. Meyer's paper (cf. this J. **14**: 4, 363) in which ogee form of spillway is defended. Purpose of this type of profile is to protect dam itself and foundation immediately under dam from direct injury due to impact of falling water, and when properly designed and constructed it has successfully fulfilled this function. Cross-section of Junction Dam on Manistee River is reproduced, illustrating use of combination of flexible apron and tumblebay to destroy excess energy and reduce scour. —*R. E. Thompson.*

Destroying Energy Below Overflow Dams. HORACE S. HUNT. Eng. News Rec., **94**: 945–6, June 4, 1925. Discussion of paper by A. F. Meyer (cf. this J. **14**: 4, 363) in which methods of destroying excess energy below dams experimented with by Fargo Engineering Co., as exemplified in dam on Muskegon River in Michigan and Junction Dam on Manistee River, are outlined. —*R. E. Thompson.*

Errors in the Use of Thermometers. B. BLOCK. Chem. App., **10**: 9–11, 19–20, 1923. From Chem. Absts., **17**: 1561, May 10, 1923. Thermometers for taking temperatures inside vessels or pipes should have long stems and narrow bulbs with thin walls and be inserted well within walls of apparatus. In taking temperatures of liquids flowing through pipes thermometer should be inserted at bend in pipe so that flow is against end of bulb.—*R. E. Thompson.*

Pouring Concrete in Zero Weather. C. N. SHANLY. Cont. Rec., **39**: 126–8, 1925. Methods of concreting in cold weather are outlined. Cost of protecting concrete during 100-day period during which average temperature was 14°F. and maximum and minimum 70° and −30° respectively, was approximately $0.50 per cubic yard, 25,309 cubic yards being poured during the period. Mass concrete was found to set satisfactorily when placed at temperature of 40–45°F., if suitably protected. Following observations by H. G. COCHRANE included. (1) Fresh concrete makes perfect bond with concrete frozen before setting and still in frozen condition. (2) Test specimens subjected to "below zero temperature" and frozen before initial set attain average of 70 per cent of strength of similar specimens cured under most

favorable conditions. Those frozen after initial set attain 80 per cent of strength, and those frozen immediately after final set 95 per cent. (3) Concrete subjected to second freezing is seriously damaged. (4) It was found that unprotected portions of concrete froze to depth of 2–4 inches overnight, and to depth of 12 inches in 2 weeks. After covering with fresh concrete, temperature of frozen portion and also of fresh concrete immediately above joint rose to 70°F. within 12–20 days.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Testing and Placarding Roadside Waters in Pennsylvania. Earle L. Waterman and H. P. Drake. Eng. News Rec., **94**: 645–6, 1925. During summer of 1924 state-wide survey of water supplies along highways of Pennsylvania was carried out by State Dept. of Health. Sanitary survey of each source was made and samples from those considered satisfactory were examined in field laboratory. Survey involved in excess of 2000 miles of highways and 1200 sources of supply; 841 supplies being sampled and 407 found satisfactory and conspicuously placarded as source of "safe drinking water." Of 275 dug wells examined, 104, or 38 per cent, were approved; of 248 drilled wells, 199, or 80 per cent, were approved; and of 162 springs, etc., 104, or 65 per cent, were approved. Study of results indicates that geologic structure was determining factor in most cases, 75 per cent of sources found unsatisfactory being in limestone and broken shale formation, while only 13 per cent of approved sources were in such formation. All sources will be re-examined before approval signs for 1925 are granted.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Ground Water Supply at Moscow, Idaho. F. B. Laney, V. R. D. Kirkham and A. M. Piper. Idaho Bureau of Mines and Geology, pamphlet No. **8**: 13 pages, maps and sections (mimeographed), December, 1923. Report of study to determine whether ground water supply is sufficient for future needs of Moscow. Water occurs in several beds of alluvium lying between beds of basalt. In 30 years head in wells in region has declined about 44 feet, and yield has decreased considerably. Quantity of water available for recharge of ground water reservoir is estimated to be more than twice present consumption. A plan is outlined to intercept entire ground water flow as far as possible by drilling a barrier of four wells across direction of flow and making explorations to develop deeper horizons than those now used.—*David G. Thompson.*

Ground Water in Santa Clara Valley, California. William O. Clarke. U. S. Geol. Survey Water Supply Paper **519**: pp. 320, 19 plates and 20 figs., 1924. A comprehensive report on ground water conditions in important irrigation region of Santa Clara valley, including also data on physiography, geology, precipitation, and stream flow. After describing general conditions affecting occurrence of ground water, estimates are given of quantity annually available in five different parts of valley. Two methods are used in making these estimates: (1) water-level method, by which available pore space in material in which fluctuation occurs is calculated from well logs

and from these data quantity of ground water gained or lost in the fluctuation is estimated; (2) absorption method, by which quantity of water lost from streams by seepage into alluvium is determined by discharge measurements at different places. Report contains data in regard to nearly 1000 wells, including frequent observations on fluctuations of water table in number of them for several years; maps showing isohyetose lines, location of wells, areas of artesian flow, contours of water table, and other ground water conditions; and graphs showing profile of the water table on different dates.—*David G. Thompson.*

On the Variations of Consumption of Water in Towns. John Bowman. Water & Water Eng., **26**: 228, June 20, 1924. Trans. Inst. of Water Engineers, **29**: 29, 1924. Growth of consumption and population from 1870 to 1923 in Edinburgh (Scotland) and district shown in figure. In 1870–71 population of about 260,000 used daily about 6,100,000 Imp. gals.; in 1922–23, respective figures were 460,000 and 21,000,000. After introduction of Moorfoot supply end of 1879, consumption showed immediate increase of about 33 per cent; after introduction of Talla, in 1904, upward tendency of consumption curve was rapid in next 7 years and gradual thereafter. Increase in domestic consumption has not been as great as in industrial. In 1871–72, trade and shipping accounted for 1.98 gallons per head per day or about 6 per cent of total; at present they take about 12 gallons or about 25 per cent of total. Present domestic consumption per head per day is given as 34.33 Imp. gals. as compared with 29.12 gallons 40 years ago, an increase of 5.22 per cent. Twelve years ago meters were placed on the 9 trunk mains delivering water into city, which for ensuing 9 years constituted entire supply. Analysis of consumption variation during this period yields following results: (1) Quarterly; variation is not 1 per cent above or below average of 25 per cent. (2) Day of the week; highest average daily consumption is about 15 per cent of total weekly consumption; and lowest, Sunday, is 12 per cent. (3) Daily; rises to nearly 30 per cent above average and falls to 70 per cent of average. (4) Time of day; from about 8 a.m. to 8 p.m., consumption is above daily average, being about 70 per cent of total daily supply; it is at lowest from 2 a.m. to 6 a.m. when it varies from 50 to 60 per cent of daily average. Table is given showing average daily consumption per head for domestic use in 62 areas with total population of 15 millions; it ranges from 14.26 to 70 Imp. gals.; in 32 cases it is 25 gallons or less; in 30 cases it is above 25 gallons; 18 of the 29 higher consmptions are in Scottish towns where houses are provided with larger number of fittings as compared with similar houses in English towns. Figures are also included to show increase or decrease in consumption during periods ranging from 5 to 60 years. In 38 areas there has been an increase due to substitution of water for earth closets and increasing installation of baths and other fittings. During 18 years, per capita consumption in London increased only 1.53 gallons from 33.54 to 35.07 gallons. In Durban, South Africa, daily domestic consumption per head is about 24 gallons out of total daily average of 60 gallons. Parker considers that for the requirements of British climate a city is well supplied which uses (abnormal waste apart) about 22–25 Imp. gals. per head per day for all

purposes, of which 15–18 gallons would be for domestic use. Allowing for waste this would amount to 30–35 gallons per head per day (36 to 42 U. S. gallons). In Edinburgh, domestic consumption per head per day varies greatly in different institutions and buildings: tenement district, no baths, 6.52–8.72 gallons; asylum, 57.7–60.8; boys boarding school, 39.7; hospital, 110.5; hotels, 80–151. Three tables contain data on velocities and flows through 73 mains of waterworks in Great Britain. In most cases velocities are under 3 feet per second.—*Geo. C. Bunker.*

Glasgow Corporation Waterworks. J. R. Sutherland. Trans. Inst. of Water Engineers, **29**: 53, 1924. Brief account of origin and development of works. Loch Katrine works were opened in the latter part of 1859 by Queen Victoria. At that time water was conveyed to service reservoir at Milngavie through old aqueduct of 1855. Act of 1882 authorized duplication of this reservoir by construction of that of Craigmaddie. Act of 1885 provided for new aqueduct, increased storage in Loch Katrine by raising water level 5 feet (making total available storage depth of 12 feet), and duplication of mains from Milngavie reservoir to and throughout city. These works were constructed gradually and last stage of work was finished in 1903. Shortly afterwards old aqueduct, in use for about 45 years, was completely overhauled. Work on new mains to city was finished in 1916 with result that eight 36-inch mains now carry water into city from service reservoirs. Loch Arklet Works, adding 14–15 million Imp. gals. per day to supply available from Loch Katrine, were started in 1909 and opened in 1914. In 1915 scheme was authorized for storing and diverting into Loch Katrine the large streams of the Glenfinlas gathering ground which will add 14.5 million gallons per day. In 1919, a 5 foot increase in storage depth in Loch Katrine was authorized, making a total storage depth of 17 feet for water supply purposes. Gorbals works were authorized in 1846 to supply large area on south side of city but can only supply about one-fifth of present requirements in this area. Recently Corporation completed purchase of lands surrounding and draining to Loch Katrine and Loch Arklet, amounting to 24,110 acres—excluding the area of the lochs themselves—at cost of £71,850. City has now complete control over watersheds, and freedom to extend and alter works and roads without being subject to serious restrictions and claims for compensation and damage which arise when land is privately owned. Illus. by sketch map.—*Geo. C. Bunker.*

Iron Deposit in Cast Iron Pipes. J. R. Fox. Water & Water Eng., **26**: 497, Dec. 20, 1924 & **27**: 21, Jan. 20, 1925. Trans. Inst. of Water Engineers, **29**: 59, 1924. Deals with incrustation in pipes carrying certain soft waters from Pennine range. Water (subjected to ordinary sand filtration) is clear with slightly yellow color, with 104 parts of total solid matter, 14.3 parts chlorine, no nitrites, 0.4 parts nitrates, 0.7 parts poisonous metals (lead, etc.), 39.3 parts hardness, 0.42 parts of iron (Fe) per million. pH of raw water is 6.5. (This sample was taken from lead service pipe which accounts for comparatively large amount of poisonous metals of which lead undoubtedly forms greater part.) Incrustation, or fur, is deposit, mostly iron bac-

teria, from water; it can be easily removed, leaving original coating; if pipe is heated and lightly hammered deposit will drop off; there is no action on iron of pipe. Analysis of deposit is: loss on ignition, 16.48; silica, 0.95; total iron as iron oxide, 79.82 per cent; alumina, etc., trace; manganese, trace. A black slime forms first all over pipe followed by continual deposition in form of reddish brown lumps. Presumably the slime is, or contains, Crenothrix which removes iron from water and thus produces incrustation. A 12-inch trunk main, laid about 55 years ago, has been reduced to 10½ inches. Incrustation is greater in distribution pipes in which there is no steady night flow; it is usually less at dead ends and greatest at bends and in hollow places; it is not regular. In a 3-inch pipe over 50 years old (not a dead end) there was a complete stoppage at one point, remainder being reduced to ½-inch or less. In general ½ to 1-inch of incrustation will form all around pipe in about 30 years; smaller distribution pipes are practically useless for proper supply in from 30 to 40 years; those of larger diameter will lose 50 per cent, or more, of their discharging capacity. Incrustation is a serious matter for three reasons: it causes shortage of supply; it reduces fire protection; and it makes water harder. Some mains, having got to state described, are relaid on account of deterioration from outside causes, but in case of majority, iron of pipe is quite sound and has many years of useful life. No rule can be laid down for relaying; some mains 80 years old are perfectly sound; others 40 years old could not be scraped owing to softening of metal from external causes. Generally speaking, of mains so badly furred as to require attention, writer proposes to relay those on which frequent bursts have occurred and those in vicinity when over, say, 50 years old, and to scrape the rest, irrespective of age. No doubt in ordinary times relaying as against scraping would take place on larger scale, but owing to comparative costs, need of all possible economy, and lengths of mains to be attended to, amount of relaying has to be kept to minimum. Cost of scraping varies with amount of fur, or other obstruction, etc., but it should not exceed 1s. 2d. to 1s. 6d. per lin. yard, according to size and state of pipe, and is therefore not more than about 14 per cent of cost of relaying smaller pipes, proportion becoming less as pipes increase in size. Use of silicate of soda is briefly discussed but no definite conclusions given; lime treatment in use for prevention of plumbo-solvency will reduce deposit of iron bacteria, iron being deposited in form of ferric hydroxide, but this treatment will cause trouble if carried out after filtration as deposit will take place in mains. Use of concrete or cement-lined pipes has been suggested and writer has put in sections of such pipe but they have not been in use long enough to furnish comparisons with unlined pipe. Recently samples were taken of a piece of straight concrete lined pipe, 6 inches diameter, and of an unlined bend which had been in use 1 year; latter had commenced to fur, but only slightly; there was nothing on piece lined with concrete except that it was slightly slimy. One of firms lining pipe found that certain amount of furring took place, but loss of carrying capacity was much smaller than in unlined pipe. Where incrustation is caused from iron in water, best remedy would seem to lie in its removal before the water enters pipes, by three methods; use of coagulants; filtration through polarite, or similar material; or aëration. **Discussion.** F. W. MACAULAY (Birming-

ham) pH of raw water from upland gathering ground of River Elan in Mid-Wales was about 5.5; treatment with small dose of silicate of soda raised it to 9.0 or 9.5; silica content was very low, about 5 p.p.m. Incrustation of cast iron and steel mains forming the siphons on Elan aqueduct was very serious. From experiments now in progress there seems no doubt that metal of pipe is very active agent in incrustation. Witness following facts: (1) Elan aqueduct consists of alternate lengths of brick or concrete-lined aqueduct and siphon mains in cast iron or steel. Incrustation and slimy deposit are confined entirely to latter, except for its occurrence upon any iron or steel surfaces in brick or concrete-lined lengths. (2) Nodular incrustation is greatest on invert, where coating of pipes had received most damage during laying of mains. Although each nodule spread over large area of apparently sound coating, under centre of most nodules examined was found a fault in coating or paint, often a hole so minute as to be invisible to naked eye, and in many cases cast iron under and around this hole had become so soft that it could be cut out with penknife. Metal of steel surfaces was almost invariably pitted under nodules. (3) Some 3 or 4 years ago a length of 42-inch cast iron double main was scraped. Result was corresponding immediate increase of capacity. About same time a parallel length of concrete-lined pipe, 60 inches in diameter, was laid. Nearly whole of increased capacity of cast iron mains had since been lost through re-incrustation; concrete-lined main had lost no capacity and showed no sign of incrustation or of slimy deposit. Analysis of nodules: moisture, 44.9; calcium sulphate, 3.33; magnesium sulphate, trace; silica, 0.55; carbon dioxide, nil; ferrous oxide, 12.9; ferric oxide, 39.32 per cent. Crenothrix and allied bacteria were found in slime. Experiments are being carried out with silicate of soda, in hopes of beneficial results from its use in the way of preventing, or at least of delaying, corrosion of the cast iron and steel. Conclusion is, from 20 years' observation of action of Elan water on concrete and iron surfaces respectively under similar conditions, that in concrete-lined pipes there would never be anything approaching amount of incrustation and deposit to be found in very few years in cast iron and steel pipes, and that, therefore, on account of assured maintenance of discharging capacity of first-named, any reasonable amount of extra first cost incurred by their adoption is more than justified. This applies to pipe of small diameters. For pipe of 42-inch diameter and upwards, properly designed steel and concrete pressure conduits could be made as cheap as, or even cheaper than, all metal cast iron or steel mains. Scraping is temporary palliative, often costly, and possibly destructive. G. R. Collinson (Tees Valley) said there were no iron or nodular incrustation of any kind in concrete pipes put in in 1905 at Swansea, although on lengths of steel and iron pipes forming part of same trunk main there was considerable incrustation. Water was from peaty moorland with characteristics similar to those of the analysis of water given by Mr. Fox. M. J. Buckley (Belfast) stated that 5-inch c.i. main, about 4½ miles long and 60 years old, was as clean to-day as when laid; water of 9 degrees (129 p.p.m.) hardness flowed through it. In about 11 miles of 36-inch c.i. and steel pipe laid as siphons about 25 years ago and carrying same water, nodules in steel pipe were not 25 per cent as many as in c.i. T. H. Tyson (Boston) men-

tioned that, prior to installation of chlorinating plant in 1922, pipes in use for about 76 years had developed incrustation, but since 1922 deposit had become somewhat softer and tended to dissolve. Mr. Fox stated that general manager of large Canadian works had informed him that by chlorinating he had not only prevented furring, but had got rid of existing fur. G. MITCHELL (Aberdeen) said that, while lining pipes with concrete gave no absolute guarantee against incrustation, the very large experience in America and the smaller experience in this country and the Continent pointed to its being successful in most cases. Dilute solution of sodium silicate had been found very effective, when applied under pressure, in reducing permeability of spun concrete pipes; he was trying it on a considerable length of large pipe.—*Geo. C. Bunker.*

Standard Arrangements for Impulse Turbines. S. C. O'GRADY. Water & Water Eng., **26**: 49, February 20, 1924. Directions for arriving at suitable lay-out and preliminary dimensions of turbine and pipeline for small hydro-electric plant. Illus.—*Geo. C. Bunker.*

The Taking of Inshore Soundings. ERNEST LATHAM. Water & Water Eng., **26**: 56, February 20, 1925. To those engaged on structural work such as piers, jetties, quays, and dolphins in tidal rivers and estuaries, taking of accurate soundings plays all important part. Article is purely practical and is written after experience of those pitfalls which marine surveyor is likely to encounter. General aspect of marine survey work of this character was covered in article in "The Engineer," page 614, June 2, 1922, in which six methods of taking inshore soundings were given. Illus.—*Geo. C. Bunker.*

The Measurement of the Discharge of the Nile through the Sluices of the Assuan Dam. (Second Paper.) H. E. HURST and D. A. F. WATT. Water & Water Eng., **26**: 61, February 20, 1924. In previous paper (Proc. Inst. C. E., ccxii, p. 228) method was described of measuring in masonry tank the discharge through certain sluices of Assuan Dam, and thence determining whole discharge of Nile. Method can only be applied during low stages from January to July and is not applicable in flood time. This paper describes the first measurements of higher stages of Nile. Current-meter of propeller type and of especially stout construction was used to map velocity distribution in the sluices. By doing this in a type A sluice, the discharge of which has been measured in the tank, the current-meter is rated against absolute volumes of water. Knowing area of cross-section of sluice-jet, relation between velocity of water and revolutions of current-meter is obtained. Repetition of process in other sluices enabled discharge of these to be inferred. Velocities ranged from 3 to 6 meters per second, and over this range rating curves of current-meters were linear. A good degree of accuracy was obtained, both in rating and in actual measurements of unknown discharges.—*Geo. C. Bunker.*

Water Power at Greenock. JAMES MACALISTER. Water & Water Eng., **26**: 219, June 20, 1924. Trans. Inst. of Water Engineers, **29**: 15, 1924. Green-

ock Corporation Waterworks holds unique position among municipal water undertakings of Scotland, inasmuch as, besides furnishing filtered water for domestic and trade purposes, it supplies large quantities of unfiltered water (a) for power purposes, by means of aqueducts and falls, and (b) for trade purposes, by means of pipes. At present Greenock water undertaking comprises 19 reservoirs, having total storage capacity of 4320 million gallons, and catchment area extending to 10,000 acres. Two water power streams are fed from this storage capacity; one, known as the Eastern Line of Lead, has 19 falls and 12 millsteads; the other, known as the New Eastern Line of Lead, has 7 falls and 7 millsteads. Total of 1,575 H.P. is available from the two leads. Rates vary from about £4 to £2 per H.P. Millowner is further entitled to benefit and use of water for such other purposes as shall not sensibly diminish quantity or affect regular and uniform passage of water to mills below, or deteriorate quality thereof so as to render it unfit for washing, bleaching, and ordinary culinary purposes.—*Geo. C. Bunker.*

Fluctuations of Annual Rainfall: Three Driest Consecutive Years. JOHN GLASSPOOLE. Water & Water Eng., **26**: 469, December 20, 1924. Trans. Inst. of Water Engineers, **29**: 83, 1924. Consideration of subject as it affects British Isles. In discussing rainfall of years 1868 to 1921, average utilized is that for period 1881 to 1915, which is closer approximation to true normal than that for whole period. The driest triennium over British Isles generally was 1887 to 1889, fall in these years being 89 per cent of average, compared with 94 per cent for the next driest triennium. Eighty per cent, or less, has occurred in period under discussion over only small fraction of the total area of British Isles, but geographical distribution is not such as to suggest its future confinement solely to those areas. There is evidence from map of mean deviation for anticipating occurrence of deficiencies of this amount in central regions of England and of Scotland. The rainfall of three consecutive years is twice as variable in central districts of England as in north-west of Ireland. Values appreciably less than 80 per cent in the 54 years are rare. Values appreciably greater than 80 per cent occur in coastal regions, and especially in north-west of Ireland. Retention of use of 80 per cent in water supply calculations seems justified, except in north-west of Ireland, where evidence of small fluctuations is so pronounced that allowance of 80 per cent could be increased. Illus.—*Geo. C. Bunker.*

The Biology of Jersey Waterworks. WILFRED RUSHTON, P. A. AUBIN, and A. J. JENKINS. Water & Water Eng., **26**: 487, December 20, 1924. Trans. Inst. of Water Engineers, **29**: 111, 1924. Jersey, largest and most southerly of Channel Islands, is situated in Bay of St. Malo, about 15 miles from coast of Normandy. Water supply is derived from watershed of St. Lawrence stream, an area of 1200 acres. Much water is derived from springs issuing from volcanic rocks, but bulk of flow is drainage from cultivated land. Average rainfall over period of 35 years was 33.68 inches and minimum was 16.67 inches in 1921. Final collecting stream enters small settling pond, whence water flows through Dannemarche reservoir (capacity, 33 million gals.), and thence through pipe line (about 1 mile long) into Millbrook reservoir

(capacity 11 million gals.). Approximately 500,000 gallons per day are filtered through open sand filters with area of 2180 square yards. Rate exceeding $3\frac{1}{2}$ inches per hour is seldom necessary and bacteria are almost entirely removed. Prior to use of Dannemarche reservoir, water did not remain long in storage and algae did not cause much trouble, but by putting it into service storage capacity was increased $3\frac{1}{3}$ times with result that water remained longer in stagnant condition and at higher temperatures; especially in lower, or Millbrook, reservoir. Weekly samples were taken throughout year at following points: inlet and outlet of settling pond; inlet at Milbrook reservoir; and inlet to filters. Investigation was undertaken to ascertain: (1) what organisms were likely to cause trouble; (2) if any such were found, when, where and how to deal with them in most satisfactory manner from point of view of management; (3) to investigate certain obscure relations between algal and fish life; (4) the most advantageous method of rearing trout under local conditions. Starting at end of April, 1923, rapid increase in Coelastrum occurred and at end of June 4576 per cc. were present in water going upon filters. Water was clear, but of deep bottle-green color. Rate of filtration was slowed very considerably, and in view of increasing consumption of water matters looked serious. Copper sulphate was applied to reservoirs as follows: Quantity equal to 0.05 parts per million gallons was dissolved in sufficient water to make a solution of 1 pound to 5 gallons; using ordinary agricultural spraying machine from a boat, whole surface of Millbrook reservoir was sprayed, and dose repeated on 3 separate days, thus making a total dose of 0.15 parts per million gallons. Dannemarche reservoir was then sprayed on 4 consecutive days, each spraying being equivalent to 0.05 parts per million. Seven days after last treatment Millbrook reservoir was again sprayed as before on 3 consecutive days making total of 0.3 parts for this reservoir. Seven days after final spraying of this reservoir green algae had decreased to 356 per cc., and at end of another 7 days to 68, from 4992 on day prior to first spraying. Similar reduction followed in other reservoir whence it would appear that 0.15 parts per million gallons was sufficient dose. For some days after treatment fermentations were slightly affected in local breweries. As yeast is extremely sensitive to the action of copper sulphate, it is essential, where breweries are supplied, to use minimum quantity. Chemical analysis failed to detect trace of copper sulphate in filtered water. Neither were adult trout, trout fry, nor the crustacea, Daphnia, staple food of the young trout, affected by treatments. Spraying of copper sulphate has following advantages over towing it in bags: (1) Salt is evenly distributed over surface instead of in streaks, in which for a time strength is sufficient to be injurious to fish life; (2) Diffusion is entirely vertical, whereas with bag method diffusion between two passages of bag is, so far as surface layers are concerned, horizontal; a slow, uncertain, process in still waters; (3) By dividing dose there is greater certainty of whole surface being treated and, moreover, if microscopic examination is carried out concurrently, treatment can be stopped as soon as desired effect is obtained. Illus.—*Geo. C. Bunker.*

Troubles, Causes and Remedies, with a Swimming Pool Using a Recirculation System. Robt. O. Friend. Jour. Amer. Assoc. for Promoting Hygiene

and Public Baths, 7: 71–74, 1925. A practical paper.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

The Development of Bathing in Holland. Mme. A. M. Ruysch Dawes-Dekker. Jour. Amer. Assoc. for Promoting Hygiene and Public Baths, 7: 66–70, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

Bath, Britain's Healing Shrine Throughout the Ages. John Hatton. Jour. Amer. Assoc. for Promoting Hyg. and Public Baths, 7: 57, 1925. Historical and descriptive, with plan and photograph of old Roman baths.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

Safeguarding the Nation's Health with Outdoor Swimming Pools. Walter S. Hood. Jour. Amer. Assoc. for Promoting Hygiene and Public Baths, 7: 50–53, 1925. Four hundred new outdoor pools will be completed this year according to the Portland Cement Association. Advantages and means of financing construction of pools.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

Saratoga's Mineral Baths. A. S. Downs. Jour. Amer. Assoc. for Promoting Hygiene and Public Baths, 7: 42–44, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

American Springs and Health Resorts. Joseph E. Gichner. Jour. Amer. Assoc. for Promoting Hygiene and Public Baths, 7: 45–46, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

The Cure at Saratoga Springs by Mineral Waters and Baths. John F. Humphrey. Jour. Amer. Assoc. for Promoting Hygiene and Public Baths, 7: 35, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

The Mineral Springs of Saratoga and Their Future Development by the State of New York. George Foster Peabody. Jour. Amer. Assoc. for Promoting Hygiene and Public Baths, 7: 31–35, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

Some Observations on Goiter. Francis E. Fronczak. Jour. Amer. Assoc. for Promoting Hygiene and Public Baths, 7: 24–31, 1925. Rochester, N. Y., preventive practice. School inspection and notification of parents of affected children. Between Sept. 11 and Oct. 2, 1923, tried for first time adding iodine to city water. Dose applied 16.6 pounds per day, or 365 pounds NaI. At tap the amount was 4 or 5 to 50 parts per billion. Dosage about 40 per cent effective. Normal content about 1 to 4 or 5 parts per billion. —*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

The Natatorium at the Zuider Park at the Hague. Anon. Bulletin trimestriel Assoc. International de Bains populaires et de Propreté, 12: 3, 11–15, 1925. Large open air natatorium opened in May, 1925. Has no equal in Europe. Pool is divided into two parts; for men and women respectively.

Each part is 50 m. x 25 m. and has a shallower part 30 m. x 25 m. Maximum depth 3.3 m. Contents of the two basins 8000 cu.m. Separating wall between the two basins may be removed to facilitate contests. Water used is iron-bearing. Filters and re-circulation system are provided.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The New Municipal Bath House at Vienna Called the Amalionbad. Johann Barousch. Bulletin trimestriel Assoc. internat. de Bains Populaires et de Propreté, **12**: 3, 1, 1925. Capacity 1250 bathers at one time. All types baths provided. Pool 12½ x 33⅓ m. Maximum depth 4.8 m. To be opened in spring of 1926.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

The New Water Supply of La Rochelle, France. Alfred Salmon. L'Eau, **18**: 63–68, June 15, 1925 and 75–78, July 15, 1925. Wells and collecting galleries at Fraise and at Anais, with pumping equipment, and concrete reservoirs. Plans and photographs. *Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

The Water Supply of Besançon. Paul Lheureux. L'Eau, **18**: 26–30; 50–54, 1925. In 170 A.D. Romans build aqueduct from Arcier springs. Other supplies have since been developed from similar sources. Greatest point of difficulty has been supply of newer and higher outskirts. Wells in the Doubs river gravel have lately been tried.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

New Intake from Lake Leman for Geneva, Switzerland. Anon. L'Eau, **18**: 55, 1925. Steel pipe 80 cm. (32 in.) diameter and 800 m. long takes water through strainer at depth of 32 m. Thickness of steel plate 5 mm. Flexibility assured by special castings permitting movement of 25° at each joint. Pipe was drawn out after assembly on shore.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

Pumping Water from Lake Leman During the Dry Weather of 1920–1. G. Kernen. L'Eau, **18**: 39–41, April 15, 1925. The towns of Lutry and Cully took water through small pipes hastily run out into lake. Lutry pipe was 100 m. long, 60 mm. (2½ in.) inside diameter. The strainer was down about 15 m. from surface and held 2 m. from bottom by six-sided wheel-like frame. Placing pipe took about two hours.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

The Romans in Northern Africa. Gaston Marguet. Semaphore Algerien, December 19, 1924; L'Eau, **18**: 10–11, 1925. Many barrages and shallow reservoirs were constructed by the Romans in southern Tunis and Algeria. They were for storage of water in spring and summer and varied from a few sq. m. to several hectares in area. Depth was seldom more than 2 or 3 m. Tunis and vicinity received its water from springs of Zaghouan and Djouggar through aqueduct of Carthage, built by Adrian, and rebuilt

by Sidi Sadok Bey in 1859. Other aqueduct supplied El-Djem and Azzefoum.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

The Water Supply of Montpellier, France. Anon. L'Eau, **17**: 123–4, 1924. Original supply completed in 1766 was from St. Clement spring and was designed by Pitot. Present supply taken from Lez spring in 1854. This water is impure at times and contains so much $Ca(HCO_3)_2$ as to cause precipitation on escape of CO_2. It is planned to chlorinate and possibly to filter and soften.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

Purification of Drinking Water. E. Rollants Rev. hyg., **47**: 534, 1925. Review of English and American articles of 1923–4.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

Apparatus for the Automatic Control of the Sterilization of Water by an Antiseptic. Igonet and de Laroche. Rev. hyg., **47**: 380–2, April, 1925. Device using two Wolff bottles, one to contain hypochlorite, controlled by displacement by flow of water through Pitot tube into second bottle.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

Standardization of Methods for the Bacteriological Analysis of Water. P. Vigne and R. Cremier. Rev. hyg., **46**: 1168–1180, December, 1925. Results of questionnaire sent to water analysts in France showed no general agreement in practices. Standardization of procedures is needed in order that there may be common basis of interpretation.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

The Sterilization of Water of Shellfish Beds. H. Violle. Rev. hyg., **47**: 33–35, 1925. Shellfish are not injured by dose of 2 to 3 p.p.m. Cl which is sufficient to sterilize sea water in 2 hours. Chlorine, after combining to form chlorides, is inappreciable when water already contains 30 to 40 g. NaCl per liter. If it takes 1 hour to kill bacteria in surrounding water, it takes 24 hours to sterilize the intervalvular water and 3 or 4 days to kill any bacteria in the pulp of the shellfish.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

Endemic Goiter and Potable Waters. F. M. Messerli. L'Eau, **18**: 14–16, February 15, 1925. Messerli's investigations have convinced him of the water-borne character of goiter. Due to use of polluted surface water, it ought to be combated by hygienic measures such as water purification. Advises continuance of iodine prophylaxis.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

The Actual State of the Endemic Goiter Problem. E. Coulaud. Rev. hyg. **47**: 5–28, January, 1925. Historical summary. Suggests that iodine deficiency is not cause of simple goiter, but that iodine is more like natural corrective, since it is claimed that goiter is reduced but not entirely suppressed by iodine treatment. Iodine treatment is not without its dangers. Likeness of goiter to bacteria-borne diseases and influence of heat on destruc-

tion of goiter-producing properties of a water are emphasized. Numerous references.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

Goiter Survey of Saginaw, Michigan. Wm. De Kleine. Public Health (Michigan), **13** (n. s.): 146–9, May, 1925. Saginaw has municipal water supply which is not safe for drinking purposes and has about 175 driven wells for obtaining drinking water. There are many private wells both shallow and deep. Survey of school children in 1924 showed that goiter was more prevalent among those using shallow wells. Chlorine in wells varied from 9 to 3350 p.p.m., and iodine from 6 to 342 parts per billion (equivalent to 0.024 to 1.3 mgm. per gallon). High chlorine does not necessarily indicate high iodine, but the two usually go together.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*).

Treatment of Boiler Feed Water by a Zeolite Softening System. S. T. Powell and J. H. Wolfe. Ind. & Eng. Chem., **17**: 6, 584, 1925. Since installation of zeolite water softener considerable economy has resulted in boiler operation at water-gas plant of Consolidated Gas, Electric Light, and Power Co. at Baltimore, Md. Practically all steam generated is used to produce water-gas, thereby necessitating 100 per cent make-up boiler feetwater. Prior to zeolite softening, frequent internal boiler cleaning was required; but since its inauguration in 1922, no cleanings have been necessary and no signs of caustic embrittlement have appeared. No serious foaming has been observed although there has been observed at times an increased tendency toward mild foaming. 81,470,000 gallons per year have been softened at an average cost of 4 cents per 1000 gallons, including labor, depreciation, salt, etc.—*Linn H. Enslow.*

Phenols, Determination of, in Natural and Polluted Waters. Loren R. Vance. Ind. & Eng. Chem., **17**: 7, 751, July, 1925. One or more liters of sample, after precipitation with caustic soda, filtration, and oxidation by hydrogen peroxide, are evaporated to 200 cc. Excess caustic alkalinity is maintained during evaporation. It is later made acid by addition of citric acid. Subsequent distillation produces an aqueous solution containing all of phenol. To an aliquot of this is added the prescribed quantity of Folin-Denis phenol reagent and one hour allowed for color development. Color is matched against colors produced from freshly prepared aqueous phenol solutions to which same reagent is added in ratio of 1 cc. for each 1 p.p.m. phenol present using 50 cc. portions for the comparisons. Sample and standards should not contain more than 4 p.p.m. phenol for accurate readings.—*Linn H. Enslow.*

Tension as a Factor in Priming of Steam Boilers. E. B. Millard and T. E. Mattson. Ind. & Eng. Chem., **17**: 7, 685, July, 1925. Experimental work in laboratory, followed by tests in small boiler, failed to furnish evidence of any connection between priming or foaming in boilers and surface tension of boiler water.—*Linn H. Enslow.*

The Water Supply of Price City, Utah. J. W. PLANT. Engr. & Contr., **63**: 781–3, 1925. Supply is obtained from Colton Springs, about 25 miles from Price. Pipe line varies from 8 to 15 inches according to grade. Vitrified tile pipe was used for 9 miles through a canyon and wood stave fir pipe for 16 miles. Installation of meters during 1921 and 1922 eliminated waste and doubled water receipts.—*C. C. Ruchhoft.*

Sanitation in San Salvador. ANON. Engr. & Contr., **63**: 1033–40, 1925. Construction of sewers, waterworks, and street paving for this Latin American city of 125,000 persons is described.—*C. C. Ruchhoft.*

Protecting the Underground Water Supply of Kearney, Nebraska. HARRY H. MOLE. Engr. & Contr., **63**, 762–64, 1925. Supply is obtained from 4 wells 400 feet apart at right angles to underground flow. All privies and cesspools lying within radius of 1000 feet from each well were condemned and sanitary sewers constructed for this area.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Water Softening at St. Paul. ANON. Engr. & Contr., **63**: 764, 1925. Lime soda process of water softening was tried at new St. Paul purification plant and hardness, expressed as $CaCO_3$, reduced from 185 to 75–90 p.p.m. This was considered most satisfactory for all round city use.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

The Laying of Cast Iron Pipes. H. H. BAUGHMAN. Engr. & Contr., **63**: 743–4, 1925. A description of ordinary methods is given.—*C. C. Ruchhoft.*

Some Notes on Electrolysis of Water Pipes. WALDO S. COULTER. Engr. & Contr., **63**: 747–50, 1925. Electrolysis caused by stray currents from electric railway systems is discussed. Insulated pipe joints, or insulated negative return conductors, are suggested as best methods for prevention.—*C. C. Ruchhoft.*

Metering the Water Supply of the City of Chicago. HENRY A. ALLEN. Engr. & Contr., **63**: 751–60, 1925. Universal metering plan, which will cost $18,000,000 in next ten years, is proposed. It is shown that if present plan is continued for thirty years, it will cost Chicago $380,000,000 more than universal metering plan.—*C. C. Ruchhoft.*

Water Purification in Ohio. H. W. STREETER. Eng. & Contr., **63**: 541–2, 1925. Results of year's survey of purification efficiencies of ten municipal water filtration plants on Ohio River are given.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Habits and Vitality of Certain Bacteria. H. W. CLARK. Eng. & Contr., **63**: 553–4, 1925. Differentiation studies on Bact. coli group from water seem to show that presence of Bact. coli indicates recent pollution; of Bact. aëro-

genes, alone, no fecal pollution; and of Bact. cloacae, contamination which is very distant, or much attenuated.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

The Improved Venturi Flume. RALPH L. PARSHALL. Proc. Amer. Soc. Civ. Eng. **51**: 7, 1340–49, September, 1925. Measurement of flowing water in irrigation practice often requires that little loss of head be sacrificed. Flume has converging inlet, parallel-sided throat, and diverging outlet. All side walls are vertical. Inlet has a level floor, each side converging at rate of 1 foot in 5 feet of length. Floor of throat slopes downward with vertical fall of 9 inches in horizontal distance of 2 feet. Outlet floor slopes upward at rate of 6 inches in 3 feet, and each wall diverges at rate of 1 foot in 6 feet of length. Lengths of throat and outlet of flume are 2 and 3 feet, respectively, for all sized flumes from 1 foot to 8 feet. Approximate discharge in second-feet = $4\ WH_a^{1.522}\ W^{0.026}$. W is width of flume, or crest length, in feet; and H_a is upper head, in feet. Increased velocity of water in throat section causes hydraulic jump below in diverging outlet, and about 70 per cent of lost head is regained. One advantage of this type of measuring device is that it will operate in sand- or silt-laden streams without trouble. Chief advantage, however, is that it operates successfully with small loss of head. —*John R. Baylis.*

Multiple-Arch Dam at Gem Lake on Rush Creek, California. FRED O. DOLSON and WALTER L. HUBER. Proc. Amer. Soc. Civ. Eng., **51**: 7, 1310–32, September, 1925. Gem Dam was built in 1915 and 1916, and is of multiple-arch type—having 16 complete arches of 40 feet each. After 8 years, concrete had partly disintegrated by freezing. It was repaired by pouring concrete gravity section back of each of arches, extending up to within 30 feet of their tops. Upper 30 feet of arches and buttresses appeared to be in perfect condition. Authors conclude that to prevent deterioration of concrete subjected to water pressure and extreme low temperatures, it is necessary that impervious concrete be obtained. Slightest penetration of water will be followed by deterioration, further penetration, and further deterioration.—*John R. Baylis.*

Permissible Canal Velocities. SAMUEL FORTIER and FRED C. SCOBEY. Proc. Amer. Soc. Civ. Eng., **51**: 7, 1397–1413, September, 1925. Laws of hydraulics governing movement of loose silt and detritus in open channels are only distantly related to laws governing scouring of a canal bed and are not directly applicable. Colloids in either material of canal bed, or in water conveyed by it, tend to cement particles of clay, silt, and sand in such a way as to resist erosive effects. Irrigation canals may be designed for velocity that is permissible when seasoned by age, as demand for water usually grows with age of canal. More conservative velocities should be chosen for canals likely to be placed under peak load shortly after construction.—*John R. Baylis.*

Side Channel Spillways: Hydraulic Theory, Economic Factors, and Experimental Determination of Losses. JULIAN HINDS. Proc. Amer. Soc. Civ.

Eng., **51**: 7, 1350–96, September, 1915. Flow may be computed by Bernoulli's theorem, using experimentally determined coefficient of loss, similar to that of friction in ordinary flow; but such coefficient would not be constant and would need to be determined separately for many different sets of conditions. This may be avoided by utilizing law of conservation of linear momentum for determining flow. Formulas for this purpose are developed. Systematic method of determining most economic design is suggested.—*John R. Baylis.*

58th Annual Report of the Commissioner of Water Works in the City of Erie, Pa., for the Year Ending December 31, 1924. 68 pp. Daily average consumption was 22,216,418 gallons, and per capita consumption 188 gallons (108 after deducting metered trade consumption). Cost of collecting, purifying, and pumping, including depreciation, was $21.927 per m.g. Addition of $230,674.46 to surplus was effected during year, notwithstanding gratuitous water supplied to City and Bd. of Education to value of $51,039.61. Number of gallons pumped per pound of coal used was 255.6. Report of filter plant includes monthly average figures for bacteriological, chemical and physical quality of raw and filtered water and data on quantities of chemicals applied. Yearly average amount of alum applied was 0.196 grains per gallon, and of hypochlorite, 0.36 p.p.m. No positive results were obtained in 616 1 cc. samples of filtered water examined for B. coli. Average cost of service laid was $21.80 and average length, 18 feet, 5 inches. Extensions to plant included four additional filter beds of 2 m.g.d. capacity each, at cost of $113,976. —*R. E. Thompson.*

A Method of Measuring the Water Temperatures of Lakes at Different Depths. FRANK A. STROMSTEN. Science, **62**: 34–6, July 10, 1925. Electrical indicating thermometer of platinum wire resistance type described, advantages of which are reliability, simplicity of operation, and rapidity in making readings. Needle of indicator usually requires 1–2 minutes to come to rest—. *R. E. Thompson.*

Corrosion of Iron. J. N. FRIEND. Iron and Steel Inst. Carnegie Scholarship Mem., **11**: 156 pp., 1922. From Chem. Abst., **17**: 958, March 20, 1923. Critical survey of present knowledge of corrosion of cast iron and steel. As general rule, cast iron containing flakes of graphite is more susceptible to acid attack than close-grained white iron. Ferrite is much more readily attacked than carbide. Alkalies have but slight effect upon cast iron. Corrosive action of water alone increases enormously with temperature. Artificially softened water is much more corrosive than untreated water. Introduction of alloying elements may effect corrodibility indirectly (e.g., silicon tends to throw out graphite, rendering metal porous and hence more susceptible) or directly (sulphur exists as sulphides, which markedly accelerate corrosion). Effect of carbon is directly dependent upon its condition. Graphite formation increases corrosion, while with combined carbon corrosion is much less. Manganese tends slightly to reduce corrodibility. Phosphorus has almost no influence on rate of corrosion and silicon has no direct influence. Concerning relative corrodibility of steel, wrought iron and cast iron, no simple

answer can be given. With neutral corroding mediums at rest, with few exceptions cast iron had lowest rate of corrosion, with steel second and wrought iron most susceptible to attack. With neutral corroding mediums in motion, in general cast iron had greatest rate of corrosion, with steel and wrought iron about equally corroded. Cast iron in general is very inferior to steel as regards resistance to all concentrations of acids. Contact between steel and cast iron increases markedly rate of corrosion over all ranges of temperature. Metals such as zinc and those more readily oxidized than iron, protect latter. In paints to protect iron against subaqueous corrosion, with increasing amount of oil and constant weight of pigment there is decided decrease in efficiency. With same weight of oil and increasing weight of pigment, protection afforded increases to point of maximum efficiency and further increase causes distinct reduction in protection. Maximum protection is effected by paint 50 per cent oil and 50 per cent pigment. Chief functions of pigment are to afford mechanical support to linoxyn and to reduce permeability. By increasing relative amount of pigment greater protection should be afforded, but there is a limit to amount of pigment that given weight of oil can efficiently bind, which when exceeded, protective power is reduced. Linseed oil is polymerized when heated in absence of air, yielding thicker litho oil which upon settling possesses minimum porosity and maximum resistance to chemical disintegration. As long as mill scale, which adheres very tenaciously, remains intact, very efficent protection is afforded, but if oxide becomes cracked, corrosion proceeds with great rapidity. Cheapest and most effective method of protection is to paint metal with scale still on, after first removing only loosely adhering flakes and rust. Influence of strain upon corrosion may be explained by studying distribution of energy absorbed in rupturing iron. As much as one half work done in stretching steel up to limit of rupture may be stored up permanently. This energy is liberated when metal is oxidized, the metal being attacked more readily, its potential rising with increased strain. This reasoning correlates with all theories of corrosion (cf. C. A. 15, 3012), and also with data obtained on stainless and high-nickel steels, which, while almost incorrodible in normal condition, are relatively very much more corroded after having been strained. Corrosion reaches maximum at temperature of approximately 80°. Plotting loss in weight against temperature accurately shows relative corrodibility at various temperatures. —*R. E. Thompson.*

New Calculations for the Determination of the Strength of Flanges. Oswald-Klinck. Chem. App., **10**: 3–4, 1923. From Chem. Abst., **17**: 1169, April 10, 1923. Mathematical formulas.—*R. E. Thompson.*

Zeolites and Their Commercial Applications. Lucien Maugé. Industrial chimique, 10: 14–8, 1923. From Chem. Abst., **17**: 1291, April 10, 1923. Description of zeolites, their manufacture and uses, particularly for water purification.—*R. E. Thompson.*

The Preparation and Comparative Performance of Base-Exchange Water Softening Materials. E. B. Higgins and J. P. O'Callaghan. Chem. and Ind., **44**: 882, September 4, 1925. Discusses early history of zeolites and

production of Permutit by Water Softeners, Ltd. States that synthetic zeolite made by weight, or precipitation, method was prepared by Water Softeners, Ltd. and marketed as Permutit 31. Formula and method of manufacture are given. Method of manufacture of Permutit Type B, made from glauconite, is given. It is stated that material made from glauconite is much more resistant to mechanical wear and effect of carbonic acid than is material made by precipitation process.—*A. M. Buswell.*

Recent Experience with Doucil as a Water-Softening Material. T. P. Hilditch and H. J. Wheaton. Chem. and Ind., **44**: 885, September 4, 1925. Points out that Doucil is not a zeolite since it has formula Na_2O, Al_2O_3, $5SiO_2$. Material therefore differs from Permutit B. No deterioration due to effect of carbonates has been observed on this material.—*A. M. Buswell.*

An Act Concerning an Investigation and Report on the Potable Water Resources of the State. Conn. Health Bull., **39**: 7, 136, July, 1925. State Geological and Natural History Survey of Connecticut is directed to report to the next session of general assembly upon water resources of the state.—*E. S. Chase.*

Physical Connections Between Public Water Supplies and Polluted Supplies. Anon. Bull. Indiana State Bd. Health, **28**: 7, 108. Indiana State Board of Health has ordered "that any and all physical connections between any public water supply, whether municipally or privately owned, and any industrial, commercial, or other water supply obtained from surface source, shall be discontinued on or before June 1, 1924, and that no such physical connection shall be made or established subsequent to the promulgation of this order."—*E. S. Chase.*

Ancient Water Systems. Anon. Michigan Public Health, **13**: 5, 153. Brief interesting account of early water supplies.—*E. S. Chase.*

Municipal Water Softening. W. C. Hirn and E. F. Eldridge. Michigan Public Health, **13**: 6, 163, June, 1925. Part of preliminary report of industrial water survey conducted in Michigan by Bureau of Laboratories of Michigan Dept. of Health. Reprint may be secured, upon request, of the Dept. at Lansing. Article deals briefly with development of water softening, use of softened water by railroads, studies on after precipitation, and chemistry of hard water and water softening. Interesting data are given to show economic loss due to use of hard water, such as excessive soap consumption, coal wasted in boilers, and installation of duplicate soft water supplies in the individual house. The subject of municipal water softening and costs thereof are also given. Distribution of hard waters in Michigan is shown by map.—*E. S. Chase.*

Report of the Bureau of Engineering, Pennsylvania Dept. of Health. W. L. Stevenson. The Listening Post, **3**: 24–26, 15. Review of activities of Bureau for two year period ending May 31, 1924. Some 172 water filter plants, serving

4.5 million people, and 330 chlorination plants, serving 1.7 million people, in service in Pennsylvania. In 1921 typhoid outbreak was caused by infected water supply. In 1923, suit for damages by widow of one victim resulted in award of $2000. This case established a precedent in Pennsylvania.—*E. S. Chase.*

The Oradell Dam of the Hackensack Water Company. NICHOLAS S. HILL, Jr. Proc. Amer. Soc. Civ. Eng., **51**: 8, 1569–90, October, 1925. Unique dam of considerable size was constructed by Hackensack Water Company in 1922. Unusual design was attempt to meet special conditions found at particular site. Spillway section is essentially an earth dam 50 to 90 feet thick at base. Up-stream face of embankment was formed by existing earth and timber crib dam with its wooden sheet-pile cut-off extending about 20 feet into the earth. Down-stream face and toe are encased in reinforced concrete envelope, supported on round piles. Continuous line of interlocking steel sheet-piling at up-stream edge of floor of concrete envelope extends to hardpan. With concrete cut-off wall of sluice-gate section, they form together continuous cut-off entirely across new dam. Earth fill forms a stable and impervious dam in itself, but is not proof against burrowing animals, nor against scouring if it should be overtopped. Reinforced concrete envelope performs function of masonry core-wall and protects top and down-stream face against scouring. Below toe of concrete envelope, stream channel is paved for distance of 45 feet.—*John R. Baylis.*

SOCIETY AFFAIRS

CALIFORNIA SECTION

The sixth annual convention was called to order at Santa Cruz by George W. Pracy, Chairman of the California Section, who presided at all of the sessions and was able to bring out much discussion of all papers, particularly the symposiums.

Morning and afternoon sessions were held in the Casino, Hotel Casa Del Rey, which also adequately housed the twenty-nine exhibits which were very attractively arranged. Evening dinner meetings were held in the main dining room of the Casa Del Rey.

The following program was presented.

Thursday, October 15

10:00 a.m.

Sun Room, The Casino, Hotel Casa Del Rey

General Get-Together, Registration and Review of Exhibits

Thursday, 2:00 p.m.

Sun Room, The Casino, Hotel Casa Del Rey

Convention called to order by George W. Pracy, President California Section, American Water Works Association.

Address of Welcome. Hon. W. O. Kerrick, Mayor of Santa Cruz.

Reading of papers

Recent Improvements in the Santa Cruz Water System. Arnold Williams, City Engineer, Santa Cruz.

Symposium: Service Installation Methods and Standards. Discussion opened by George Read, Superintendent, Meter and Service Department, Bureau of Water Works and Supply, Los Angeles, California. Read by A. P. Lovell, Supt. Water, San Diego.

Symposium: Meter Maintenance Methods. Discussion opened by J. H. Fagg, Pacific Gas & Electric Corporation, Stockton, California. Read by G. E. Sedgwick, Dist. Mgr., Pacific Gas & Electric Co., Dixon, California.

Thursday, 6:30 p.m.
Informal Dinner
Hotel Casa Del Rey

The Secretary reported the admission during the year of 22 active, 2 corporate and 4 associate members, making 28 in all. There were 2 resignations, B. J. Robinson and J. C. McCoughern, making a net growth of 26, bringing our present membership to 1 honorary, 103 active and corporate, 11 associate—total membership, 125; the result of this growth being the award of the Nicholas S. Hill cup.

The Treasurer reported expenses of stationery, printing and postage for the 1925 Convention amounting to $80.10, leaving a balance of funds in the bank of $106.90.

The Nominating Committee, composed of past Chairmen G. A. Elliott, Chairman, L. M. Anderson, Fred J. Klaus, brought in the following nominations.

C. B. Jackson, Chairman; S. B. Morris, Vice-Chairman; P. Diederich, Member of Executive Committee; John Burt, Member of Executive Committee; Paul E. Magestadt, Secretary-Treasurer.

On motion by Mr. Ryland, seconded by Mr. Prugh, the above nominees were unanimously elected.

A. P. Lovell, Superintendent Water Department, San Diego extended an invitation to the Association to hold their next Convention in the City of San Diego, which was accepted on motion by Mr. Anderson.

Fred M. Randlett, Member of the Governing Board of the American Water Works Association, gave an interesting talk of the work of the Association, particularly describing the water works manual and offering his regrets at not being able to present the Nicholas S. Hill cup to the Section during the Convention, owing to its non-arrival.

Leslie Cranborne, Secretary, Chamber of Commerce of Santa Cruz, gave a very interesting address upon State Unity and Conservative Development. He also spoke entertainingly of the win-

ning of the title of Miss America, the Santa Cruz Entry at Atlantic City.

The "Orpheus Four," of which H. M. Dudley, of the McWane Cast Iron Pipe Company, is a member, gave a number of excellent selections through the courtesy of his Company.

There were present 142 members and guests.

Friday, October 16

10:00 a.m.

Sun Room, The Casino, Hotel Casa Del Rey

Reading of Papers

Design and Construction of Concrete-Lined Distribution Reservoirs. I. E. Flaa, Chief Draftsman, Spring Valley Water Company, San Francisco, California.

Design of Balancing Reservoirs and Stand-Pipes for Flat Cities and Communities. E. K. Barnum, Engineer, Fresno City Water Corporation.

Seismic Activity in Santa Barbara, by V. E. Trace, Supt. Water, Santa Barbara. Read by S. B. Morris, Superintendent and Chief Engineer, Pasadena Water Department.

Symposium: Jointing Methods for Water Mains. Participated in by J. I. Prugh and 15 other members present.

Friday, 2:00 p.m.

Sun Room, The Casino, Hotel Casa Del Rey

Reading of Papers

Relation of Railroad Commission to the Water Works Man. M. R. MacKall, Hydraulic Engineer, California State Railroad Commission.

Coöperation between the Water Works and Fire Departments in Decreasing Fire Losses. Thomas Baird, Chief Engineer, Fire Department, Fresno, Calif.

Adjustments. Frank P. Clark, Chief Adjuster, Spring Valley Water Company, San Francisco, California.

Methods Used in Moving 36-inch Riveted Steel Water Main. Judy I. Prugh, Superintendent Distribution, Sacramento Water Department.

Relation of Water Pressures, Service Sizes and Interior Fixtures to Complaints of Inadequate Water Service. V. E. Perry, Assistant Manager of Water Sales, Spring Valley Water Company, San Francisco, California.

Methods of Protecting Services and Meters during Street Grading and Paving Operations. P. Diederich, Supt. Public Service, Glendale, Calif.

Use of Mechanical Equipment in Trenching, Backfilling and Pipe Laying, by Thomas Brooks, Assistant Superintendent, Bureau of Water Works and Supply, Los Angeles, California. Read by Wm. F. Goble, Superintendent San Gabriel Valley Water Company.

The Secretary was instructed to address letters of appreciation to Mr. Pratchner and the Local Committee; Mr. W. O. Kerrick, Mayor, and to the City of Santa Cruz; Mr. Leslie Cranborne, Secretary, and to the Chamber of Commerce of Santa Cruz; Mr. R. W. Martindale and the Exhibitors Committee, and to Mr. Fred K. McDonald, Manager of the Hotel Casa Del Rey. The retiring officers were thanked by resolution passed by the meeting.

Friday, 6:30 p.m.

Hotel Casa Del Rey

Dinner Dance—Informal

As Guests of the Exhibitors

Members and guests were entertained with several dances and soprano solos and by the "Orpheus Four" through the courtesy of the Exhibitors. Following the dinner, dancing was enjoyed until 1 a.m. There were 229 members and guests present.

Saturday, October 17

As guests of the City and Chamber of Commerce of Santa Cruz, the members and guests of the Convention went on an automobile trip through the City of Santa Cruz where the Water Department's new distribution reservoir was inspected, and thence along the Cliff Drive, stopping at the Country Club at Aptos for luncheon, 76 sitting down for lunch.

Following the luncheon, W. K. Dodworth of Monroe, Lyon and Miller, Inc. led the party through their 2500 acre development of

seaside and mountain homesites, after which the party returned to Santa Cruz where inspection was made of the City's pressure filter pumping plant. From here members drove to "Big Trees" in the Giant Redwood Forest near Santa Cruz, returning to Santa Cruz at 4 p.m.

Through the courtesy of the city and chamber of commerce of Santa Cruz, the ladies present at the Convention were entertained Thursday evening by a theater party and on Friday afternoon by a drive about the City and to the Giant Redwood Forest.

Throughout the Convention there was much discussion of every paper and all persons at the Convention, both members and guests, returned with a feeling of days well spent and are looking forward to the Seventh Annual Convention at San Diego.

There were registered during the Convention 105 water works men; 75 material men; 21 students and others and 46 ladies, making a total registration of 247.

CORRECTION

In the November, 1925, issue of the JOURNAL, p. 458, "Mr. Childs" should read "George G. Schaut." The stenographers credited Mr. Childs with the discussion on "Tastes and Odors."

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

Vol. 15 FEBRUARY, 1926 No. 2

CONTENTS

OFFICERS OF THE
AMERICAN WATER WORKS ASSOCIATION (Continued)

Central States Section.—President, JOSEPH W. ELLMS; Vice-President, CHESTER F. DRAKE; Secretary, E. E. BANKSON; Trustees, J. C. BEARDSLEY, D. C. GROBBEL, MENTOR HETZER.

4-States Section.—President, EDGAR M. HOOPES, JR.; Vice-presidents, V. BERNARD SIEMS, JOHN C. TRAUTWINE, JR., L. VAN GILDER,; Secretary-Treasurer, CHARLES R. WOOD; Executive Committee, M. E. BARTLETT, W. H. BOARDMAN, H. D. BROWN, J. W. LEDOUX, GEORGE MCKAY, and the officers.

Illinois Section.—Chairman, L. R. HOWSON; Vice-Chairman, W. R. GELSTON; Secretary, G. C. HABERMEYER; Treasurer, H. E. KEELER; Trustees, W. E. LAUTZ, C. M. ROOS, H. M. ELY.

Indiana Section.—Chairman, J. O. ENDRIS; Vice-Chairman, WM. LUSCOMBE; Secretary-Treasurer, C. K. CALVERT; Assistant Secretary-Treasurer, B. J. T. JEUP.

Iowa Section.—Chairman, MAX LEVINE; Vice-Chairman, HOMER V. KNOUSE; Secretary-Treasurer, J. J. HINMAN, JR.; Directors, J. W. MCEVOY, N. T. VEATCH, JR.

Kentucky-Tennessee Section.—Chairman, C. E. DAVIS; Vice-Chairman, W. S. PATTON; Secretary-Treasurer, F. C. DUGAN; Directors, F. W. ALBERT, W. H. LOVEJOY.

Minnesota Section.—Chairman, C. M. CROWLEY; Vice-Chairman, J. A. CHILDS; Secretary-Treasurer, ARTHUR F. MELLEN; Trustees, CHAS. FOSTER, A. D. HORNE, E. MCCULLOH.

Montana Section.—HERBERT B. FOOTE, Acting Chairman.

New York Section.—President, B. B. HODGMAN; Secretary, E. D. CASE; Board of Governors, E. D. CASE, B. B. HODGMAN, F. T. KEMBLE, THADDEUS MERRIMAN.

North Carolina Section.—President, J. O. CRAIG; Vice-President, M'KEAN MAFFITT; Secretary-Treasurer, THORNDIKE SAVILLE; Executive Committee, G. F. CATLETT, E. G. MCCONNELL, H. E. MILLER, A. O. TRUE, W. E. VEST, and the officers.

Wisconsin Section.—Chairman, W. D. LEONARD; Vice-Chairman, EDWARD BROWN; Past Chairman, L. A. SMITH; Secretary-Treasurer, C. M. BAKER; Director, WILLIAM KOEHN.

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

VOL. 15 FEBRUARY, 1926 No. 2

BALANCING RESERVOIRS TO SUPPLEMENT PUMP CAPACITY DURING PEAK DEMANDS[1]

BY EDMUND K. BARNUM[2]

In cities where the topography is more or less level and natural, elevated storage sites cannot be obtained, the question of meeting the maximum hourly demand with pumps or gravity water becomes a problem of designing the works to meet the peak conditions or supplement the above with stored water, from elevated tanks or surface reservoirs with booster pumps. In the former case a large investment in major equipment results, with corresponding fixed charges often passing the economic limit, while in the latter case, we are confronted with the problem of balancing annual operating expense, plus fixed charges on our pumping equipment, against that of meeting the peak demand or a percentage thereof, with stored water from balancing reservoirs.

As the economics of the problem require a careful study of load factor conditions, on each particular system, before storage capacity should be decided upon, this phase of the problem will be touched upon but briefly, as it is believed the economics to be somewhat outside of the scope of this report.

A hypothetical water works plant will be considered, and a method outlined of determining the relationship between maximum hourly demand and pump capacity versus storage requirements.

[1] Presented before the California Section Meeting, October 16, 1925.

[2] Engineer, Fresno City Water Corporation, Fresno, California.

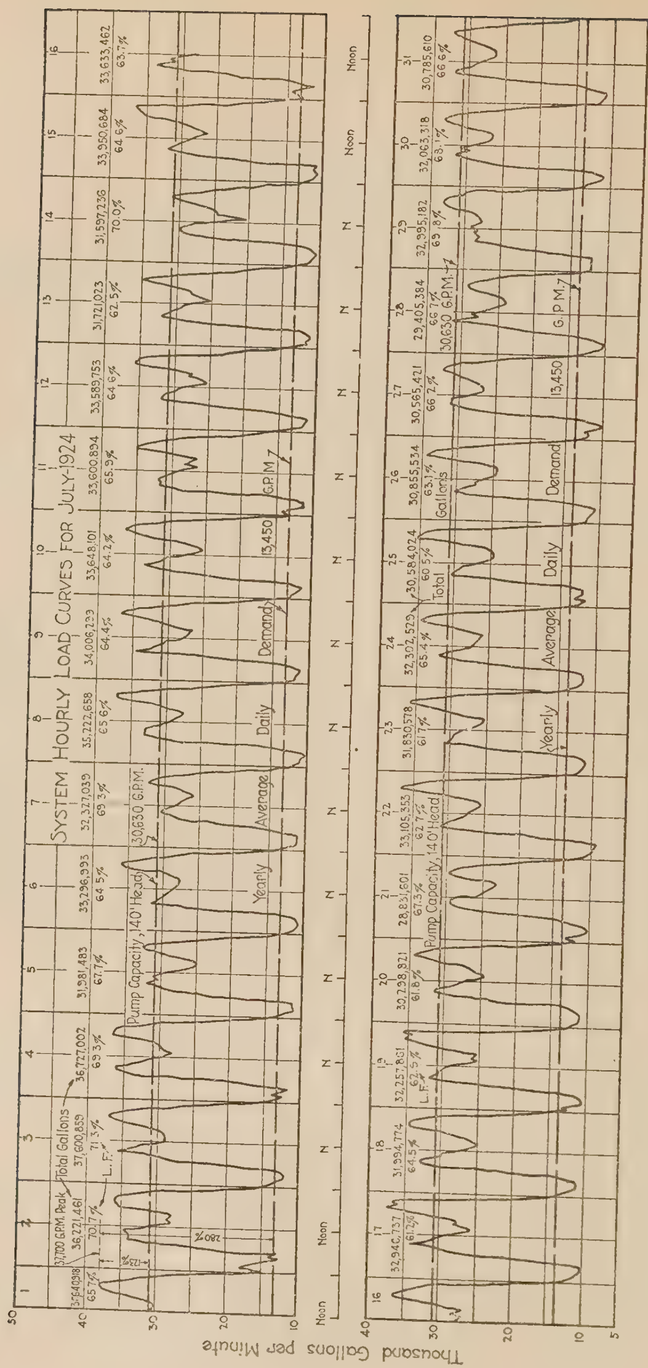

SYSTEM HOURLY LOAD CURVES FOR JULY-1924
Thousand Gallons per Minute
37,700 G.P.M. Peak
Total Gallons
L.F.
Pump Capacity, 140' Head
30,630 G.P.M.
Yearly Average Daily Demand 13,450 G.P.M.
Noon

FIG. 1

A city of 80,000 inhabitants will be considered operating on a flat rate basis, the average daily demand being 19.5 million gallons total consumption of water measured at the pumps. We shall assume that the supply is being pumped from the underground waters, and that the plants are distributed throughout the city and pump directly into the mains. Any additional pumping plants must be so located that interference between wells or overlapping of cone of depression will not be obtained, and that there is a limit to the number of pumps which can safely be installed in the area considered.

Figure 1 is submitted herewith and shows the hourly load curve for the maximum month of the year studied, and represents the demand expressed in gallons per minute. The total consumption for the month is 1016 million gallons or 22,750 gallons per minute; this represents an average monthly load factor of 60.4 per cent. From a study of the performance curve of each pump, the capacity in this case was taken at a total head of 140 feet and then summarized, the result being the available supply at such a head, (namely 140 feet) that normal service could be rendered. This is seen to be 30,630 gallons per minute. At all points wherein the demand curve is seen to be above the available supply line, then auxiliary capacity is required either in the form of additional pumps or storage released. It is to be noted that there are only three or four days of the entire month that normal service could be rendered with the present pump capacity.

In order further to study the condition, the three maximum days have been selected from figure 1, and reproduced on figure 2, together with a mass curve showing accumulative pumpage for this period. The mass curve is of the usual form, the demand line being accumulative pumpage, while the supply line represents available supply at 140 feet total head. Any line parallel to the supply line, and drawn tangent to the demand line, has a maximum ordinate whose value represents deficiency in supply. This is further shown on the hourly load curve, as all areas above the available supply line, can be integrated and storage requirements determined. Summarizing the above, then, it is seen that:

(1) The average daily demand for the year = 19.5 m.g.d.
(2) Pump capacity at 140 feet head = 30,630 g.p.m.
(3) Maximum hourly demand (three day average) = 36,764 g.p.m.

(4) For approximately 10 hours for each of the three days selected, the demand was equal to or greater than the available supply, resulting in service being rendered at a reduced pressure head
(5) Pump capacity in per cent of average daily demand = 227
(6) Peak demand (three day average) in per cent of average daily demand = 273
(7) Peak demand in per cent of pump capacity = 120

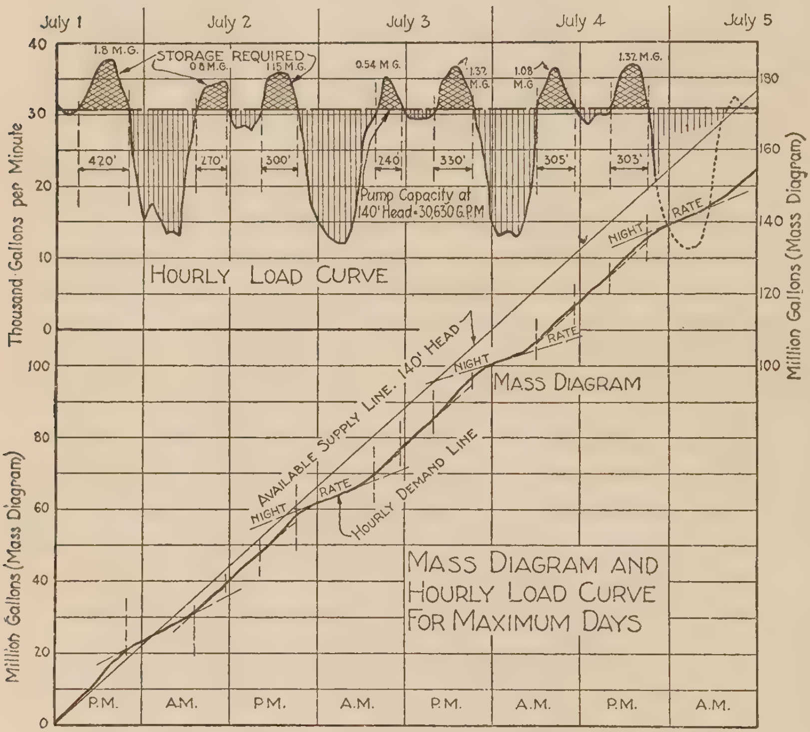


FIG. 2

By reference to the mass diagram it is seen that the average night rate of flow is about 12,500 g.p.m., while the average rate during maximum demand period is about 33,000 g.p.m., or approximately 264 per cent of the night flow.

Figure 3 is now plotted as an average curve for the three maximum days and reflects the average system operating conditions from which final conclusions may be drawn, as to deficiency in supply during peak demand period, and pump capacity. From 4:00 p.m. until

9:30 p.m. it is obvious that the pump capacity should be either increased or auxiliary supply furnished in the amount of 1.35 m.g. If reservoirs are provided the 1.35 m.g. mentioned above, and about 600,000 gallons during the morning load, or from 7:00 a.m. to 11:30 a.m. or about 20 per cent more capacity is required to equalize the flow during peak conditions.

The operating condition of the system during this three day maximum period are shown in figure 4. It is seen at once that, to supply the peak demand of 36.764 g.p.m., storage or auxiliary supply is necessary; with a pump capacity of 30,630 g.p.m., representing approximately 227 per cent of the yearly average daily demand, there remains a deficiency in the amount of about 17 per cent of

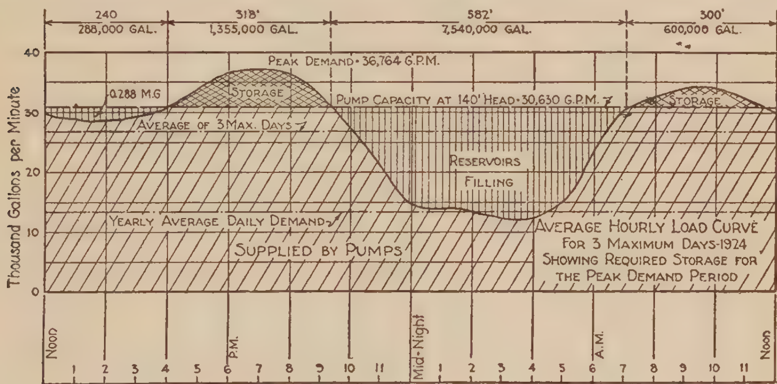


FIG. 3

the peak demand to be provided. Figure 4 is further useful in the determination of the economic solution of this problem, as the cost of storage expressed in terms of per cent of peak capacity is readily balanced against the cost of equivalent pump capacity in terms of per cent of yearly average daily demand.

It is assumed herein that, if storage is to be provided, it will be utilized throughout the year, and the pumping plant so operated that maximum use of stored water will be obtained. By this scheme of operation certain plants may be shut down as the average daily demand decreases, allowing the remaining plants to operate at a higher load factor and efficiency, which is very desirable in a system of this kind.

The economics of storage versus additional pump capacity should

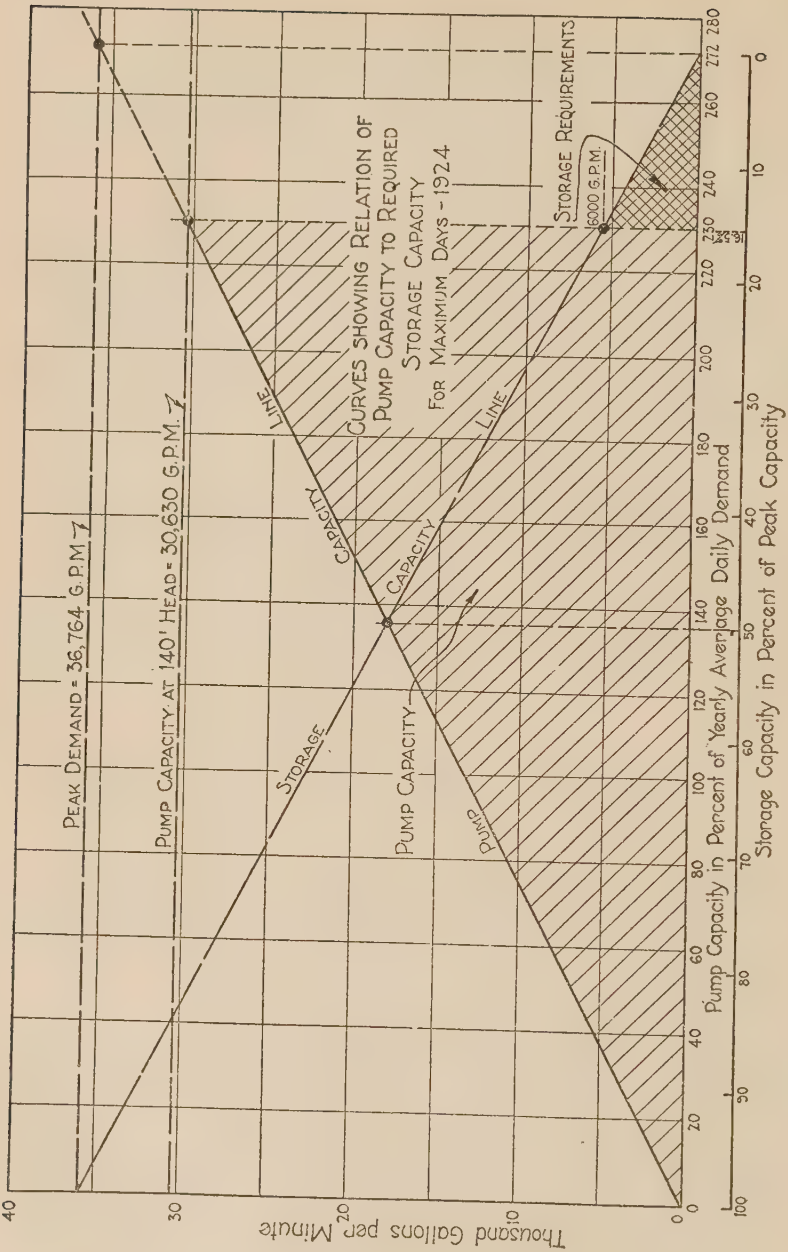

Curves Showing Relation of
Pump Capacity to Required
Storage Capacity
For Maximum Days - 1924
Peak Demand = 36,764 G.P.M.
Pump Capacity at 140' Head = 30,630 G.P.M.
Storage Requirements
6000 G.P.M.
Pump Capacity
Pump Capacity Line
Storage Capacity Line
Thousand Gallons per Minute
Pump Capacity in Percent of Yearly Average Daily Demand
Storage Capacity in Percent of Peak Capacity

Fig. 4

now be studied, and the annual cost of operation plus fixed charges of both schemes balanced. There will be found a point or a balanced condition wherein the total annual cost of operation of pumping plants, expressed as a percentage of average daily demand, will be equal to the corresponding annual cost of operation of storage reservoirs, expressed as a percentage of the peak demand. Having found this balanced cost condition and it is deemed desirable to store water in elevated reservoirs, the pressure conditions in certain selected zones should be scrutinized and the average pressure per hour plotted, as shown on figure 5, from which the proper elevation of stored water may be obtained.

Recording pressure charts are almost indispensable in the pressure survey. These should be carefully adjusted and proper calibration maintained. I find it convenient, in a study of this kind,

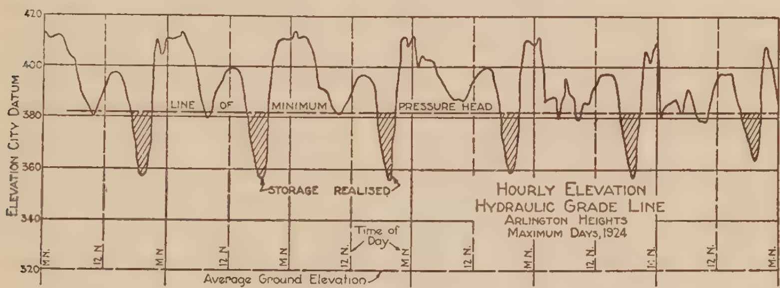


Fig. 5

to determine the elevation of these gages referred to City Datum from which the elevation of hydraulic grade at any point on the system is noted, and comparison is made.

Referring to figure 5 again, your attention is directed to the hourly pressure, and a suggested method of determining the dimensions, and elevation of elevated reservoirs for this particular case. If the tank is to operate automatically, and fill from the mains during the off peak hours, and discharge during periods of large draft, then the bottom of the reservoirs should be placed at such an elevation that a reasonable pressure head will be maintained until the heavy draft has stopped, and the pressure rises in the mains to the point of filling the tank. Sufficient friction head should be allowed between the pressure head in the mains and the capacity line in the reservoir so that the tank will fill rapidly during the off peak hours. An estimate of the required friction head, can be obtained by again

turning to the mass diagram. It will be noted that the lines B-B are drawn parallel and tangent to that portion of the mass diagram, which indicates the night flow. The rate of flow for this period is seen to be about 12,500 g.p.m. for the two twenty-four-hour periods studied. If reservoirs are provided to the amount of $2\frac{1}{4}$ m.g., then they also must be filled during this period which will increase the night rate of flow by the time decided upon to fill the reservoirs. An estimate can then be made of the allowable time to fill the reservoirs from which the proper friction head can be determined.

SUMMARY AND CONCLUSIONS

Before an extensive construction program is undertaken for a City, in which the problem is one of pumping from the underground waters, and the consumption of water is relatively high, the water department would do well to make a comprehensive study of the rate of growth in the past, and forecast the future conditions which are likely to be met. Based on this study, pumping plant sites should be selected and the distributing system so designed that balancing reservoirs of economic capacity may from time to time be added. Balancing reservoirs of suitable capacity based upon an economic study can be provided to equalize the maximum hourly demands throughout the year, thereby allowing pumping plants to operate at a higher average annual load factor, with resultant better efficiency and corresponding saving in power.

Reservoirs in the form of elevated tanks, or stand pipes, are easily constructed and maintained. Their economy in annual costs offer a solution in many cases to meeting the peak conditions. Their adaptability to smoothing major fluctuations in pressure is recognized. An altitude valve or other automatic device should preferably be installed in the discharge line of the tank, thereby, allowing complete automatic behavior.

Frequently a slight elevation can be found in cities, even though the general topography is assumed to be flat. In this case there is sometimes experienced some difficulty in serving consumers, particularly on the peak. This case may be treated separately, and the district isolated by means of check valves in the trunk supply lines, and storage provided sufficient to care for the demand, based on local studies, rather than the system condition. It is obvious that the check valves should be so located and the tank be placed at such an elevation that flow during off peak hours will store the water,

and it will be ready for use when the next cycle of lowering of system pressure occurs.

Stored water is also an asset from the point of view of fire protection. It should be given some weight in this consideration, more so perhaps, if the entire supply is being pumped, than if it is from a gravity source.

Regarding the aesthetics of elevated tanks and towers, much can be said. The conventional design of elevated tanks and steel towers may be so modified as to harmonize with the surrounding buildings and structures.

DESIGN AND CONSTRUCTION OF CONCRETE-LINED DISTRIBUTING RESERVOIRS[1]

By I. E. Flaa[2]

FUNCTION

Distributing reservoirs are used for receiving water from long conduits, leading from the source of supply into the cities and there regulating the flow into the distributing system. This regulation of flow is necessary due to variation of consumption during a twenty-four-hour period, the maximum consumption for a short period being greater than the carrying capacity of the conduit, and also to give a continuous supply to the district during the period of shut down on the conduit due to accident or other causes.

Distributing reservoirs are also used for regulating the flow and pressure in pumping systems.

The capacity and location of distributing reservoirs depend upon the requirements of the district to be served. The type depends upon the physical character of the available sites.

Among the important types are the

1. Excavation and rolled embankment in earth with the necessary impervious lining
2. Concrete, steel and wood tanks
3. Standpipes

In a distributing system it is desirable to maintain a pressure between 40 and 50 pounds at the tap. Thus it will be seen that in any city, having a wide range of elevation, in order to maintain the pressure of 40 to 50 pounds, the area must be divided in zones between every 100-foot rise in elevation, thus requiring some regulating device for each zone or pressure district. A flat city will require only one regulating reservoir or possibly two.

In San Francisco, with elevations varying from sea level to nearly 1000 feet above sea level, seven distributing reservoirs and fourteen

[1] Presented before the California Section meeting, October 16, 1925.

[2] Office Engineer, Spring Valley Water Co., San Francisco, Calif.

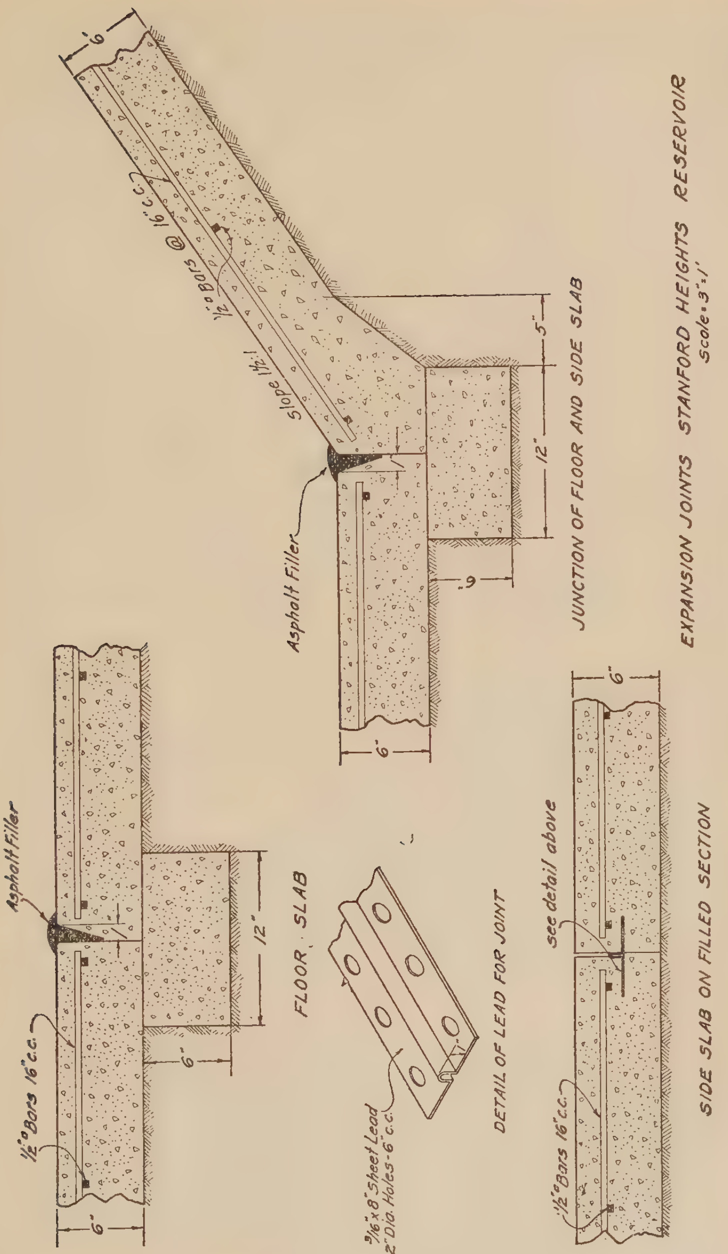

EXPANSION JOINTS STANFORD HEIGHTS RESERVOIR
Scale = 3" = 1'
JUNCTION OF FLOOR AND SIDE SLAB
½"⌀ Bars @ 16" c.c.
slope 1½:1
Asphalt Filler
6"
5"
12"
9"
FLOOR SLAB
Asphalt Filler
½"⌀ Bars 16" c.c.
6"
12"
DETAIL OF LEAD FOR JOINT
3/16" x 8" Sheet Lead
2" Dia. Holes-6" c.c.
SIDE SLAB ON FILLED SECTION
see detail above
½"⌀ Bars 16" c.c.

Fig. 1

tanks are required at the present time to regulate properly the flow in the nineteen major pressure districts into which the city is divided.

The East Bay Cities of Oakland, Alameda, Berkeley, Hayward and Richmond, with towns and communities in between, served by the East Bay Water Company, with a variation in elevation from sea level to 1400 feet above sea level, require 25 reservoirs and 17 tanks.

In Sacramento, which is flat, only one reservoir is used and that is in conjunction with the present filtration plant.

In San Jose, another flat city, one reservoir is used.

Tanks and standpipes, being more or less standardized in their construction, will not be discussed in this paper.

The excavation and rolled embankment reservoirs require a detailed study in each and every case. First, the location is limited to a predetermined elevation, there being only a relatively small number of available sites at the particular elevation required in the proximity of the district to be served, a study must be made to determine which one lends itself to the most economic construction.

Of the 7 distributing reservoirs in San Francisco 6 were built between 1860 and 1897:

Lombard Street reservoir built in 1860, was excavated in solid rock with low embankment lined with brick.

Lake Honda reservoir built in 1861, is a natural basin, sides trimmed and these trimmings placed in bottom. Portions of both the sides and bottom are lined with brick and a portion with concrete.

College Hill reservoir built in 1870. Excavation and tamped embankment with a lining of clay over which was placed riprap.

Francisco Street reservoir built in 1860. Excavated in solid rock with tamped earth embankment, lower side lined with brick and concrete.

University Mound built in 1885. Excavation and rolled embankment lined with concrete, felt and asphaltum.

Potrero Heights reservoir built in 1897. Excavated in solid rock and lined with brick.

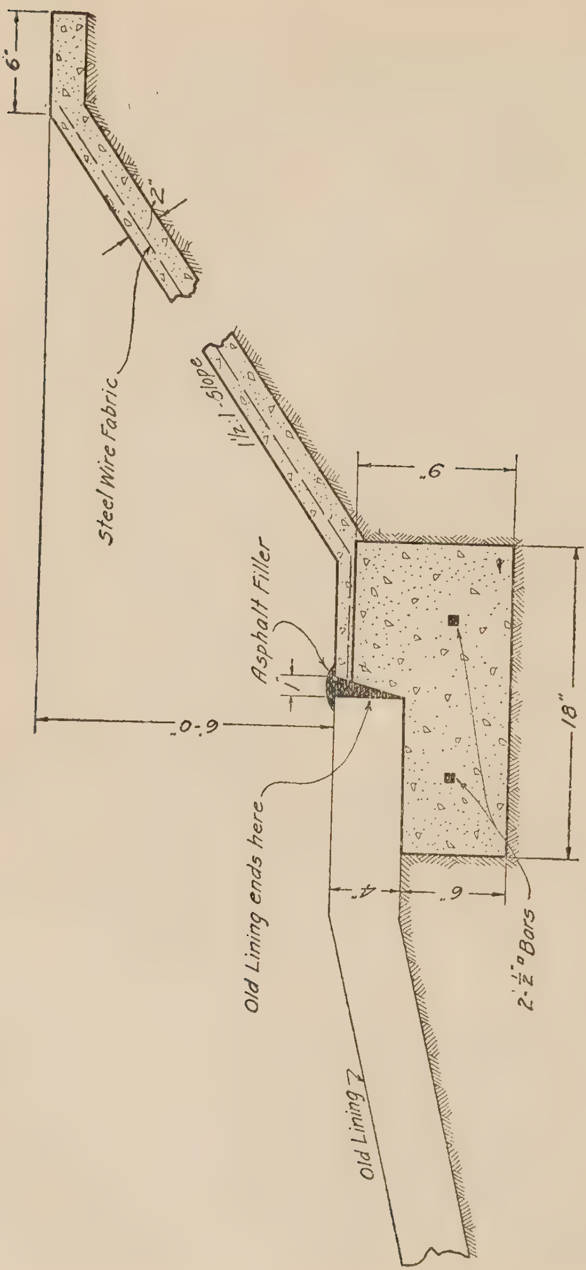
Only one of these reservoirs was covered and that covering was burned down in 1906 and was not replaced until 1919.

In the earlier years of the Company's development it was found unnecessary to cover distributing reservoirs to eliminate contamination from algae or other sources, but in the past twenty years the sea gulls have increased in great numbers and seem to have an affinity for fresh water, persisting on congregating in and about the open reservoirs causing more or less trouble.

The reason for the ever increasing numbers is that they are now protected by law. In the olden days, as now, the gulls hatched and reared their young on the Farallon Islands about 25 miles out in the ocean west of San Francisco. These eggs were collected by certain individuals and sold in the markets as food, and were used principally in the baking and confectionery trades. The gulls were also shot and used as various forms of chicken particularly in the chicken tamale. If this condition were allowed to continue the sea gulls would have become extinct in this section. Thus with the protection that this lowly scavenger now enjoys he has become an item of importance in reservoir construction. In 1919 due to this sea gull trouble it was found necessary to cover our Francisco Street reservoir—and all reservoirs built since that time have been covered.

In the past three years the Spring Valley Water Company has constructed two concrete-lined reservoirs, each having a storage capacity of 5 million gallons, and have increased the storage capacity of a third—the University Mound reservoir—from 41 to 59 million gallons, a gain of 18 million gallons storage, by raising the present embankment 6 feet and lining it with concrete. In the two 5 million gallon reservoirs recently constructed the general problems of design were similar but the method of construction and some of the details were different. One of these, the Stanford Heights reservoir, located in the western portion of the city at elevation 600, was constructed to meet the increased demand of the new residential district between elevations 400 and 500 in that region. It is located on a hillside having a slope of about 7 horizontal to 1 vertical. A full city block 663 feet long and 228 feet wide was available at the particular elevation and location. An excavated and rolled embankment reservoir for 10 million gallon storage was designed to cover the entire block, with a reinforced concrete division wall in the center dividing it into two equal parts.

For our present needs only one-half capacity or 5 million gallon storage was required so the westerly half was constructed in the spring of 1923. This portion is 300 feet by 155 feet on top, 215 by 88 feet on the bottom, and is 22 feet deep with inside side slopes of $1\frac{1}{2}$ to 1 and outside embankment slope of 2 to 1, and crest of embankment 10 feet wide. It is lined with a 6-inch slab of reinforced concrete placed in 30-foot squares on the bottom and 20-foot by 40-foot sections on the sides. This lining has a total of 0.5 per cent temperature reinforcing, or 0.25 per cent in each direction, consisting of $\frac{1}{2}$-inch



EXPANSION JOINT-JUNCTION OF OLD AND NEW WORK.
UNIVERSITY MOUND RESERVOIR
Scale=3"=1'.

FIG. 2

square bars spaced 16 inches both ways; each section is separated from the adjoining section by expansion joints which will be referred to in detail later. A tar and gravel roof is supported by 8-inch by 8-inch precast reinforced columns 24 feet long spaced 20 feet apart; these columns are reinforced with four $\frac{1}{2}$-inch bars and were set in precast concrete footings grouted to the floor and side slabs. The roof beams are two 3-inch by 12-inch Oregon Pine, 20 feet long, rafters are 2 inches by 8 inches by 20 feet long, spaced 30 inches, on which is placed a 1-inch by 10-inch pine flooring covered with a paper tar and gravel covering. The excavation and rolled embankment was made as if the entire 10 million gallon reservoir was to be finished, leaving the easterly end open. This end was closed by a reinforced concrete division wall designed and constructed to withstand the full head of water from either side, the other side being empty. This wall is 22 feet high 10 inches thick on top and 15 inches thick on the bottom and is supported with 14-inch thick counterforts on both sides spaced about 9 feet apart. The wall and counterforts rest upon a slab of concrete 20 feet 3 inches wide and 22 inches thick. The outlet gate and screens are contained in a square concrete tower set in the division wall and made a part thereof. It is divided into three compartments, so arranged that either half of the ultimate 10 million gallon reservoir can be operated independently of the other half. Two 24-inch cast iron pipes lead from the tower through a concrete culvert under the embankment to the mains in the street and one 12-inch cast iron drain pipe connects with the sewer.

Bids were called for, the contractor to furnish labor and material, excepting the pipe, sluice gate, gate valves for the outlet works. These were to be furnished and installed by the owner. The owner also was to furnish and place the plastic material in the expansion joints. Three bids were received ranging from $62,400 to $70,200, and the lowest bidder got the job for $62,405.50.

A steam shovel was used for excavating and the material transported to the embankment by dump wagons where it was spread in 4-inch layers, wet down and rolled with 10-ton roller. This excavation was carried to within 2 or 4 inches of the final grade, then trimmed to grade and made ready for the concrete lining; during the excavation, springs were encountered which were drained by a 6-inch cast iron pipe along the toe of cut on the uphill side, thence under the division wall through the embankment on the downhill side. No further trouble was encountered from that source. After the

floor and side slabs were poured the roof columns were erected by a derrick using a Ford truck for power which ran on the completed floor.

The contractor finished his work in three months. The owner then cleaned the expansion joints and placed the plastic material, which in this case was a patent compound—a combination of tar and asbestos filler.

This material was delivered on the job in barrels, which when opened was found to be of different consistency. Some was so thin that it could not be poured in the side joints but was used on the floor. The rest was thick enough to be placed with a trowel. After this experience an inspector was placed at the plant where this material was made and from then on the material received was of proper consistency.

Two types of expansion joints were used. In the embankment lead joints were used and on the cut portion tar joints were used.

NILES RESERVOIR

Niles reservoir, as the name implies, is near the town of Niles, Alameda County, about 30 miles southeast of San Francisco, and serves as a regulator at the head of the pipe line leading from that point into the city. It receives its water from the recently reconstructed concrete aqueduct in Niles Canyon. This aqueduct consists of four covered concrete flumes and five concrete-lined tunnels, and has a capacity of 70 million gallons daily.

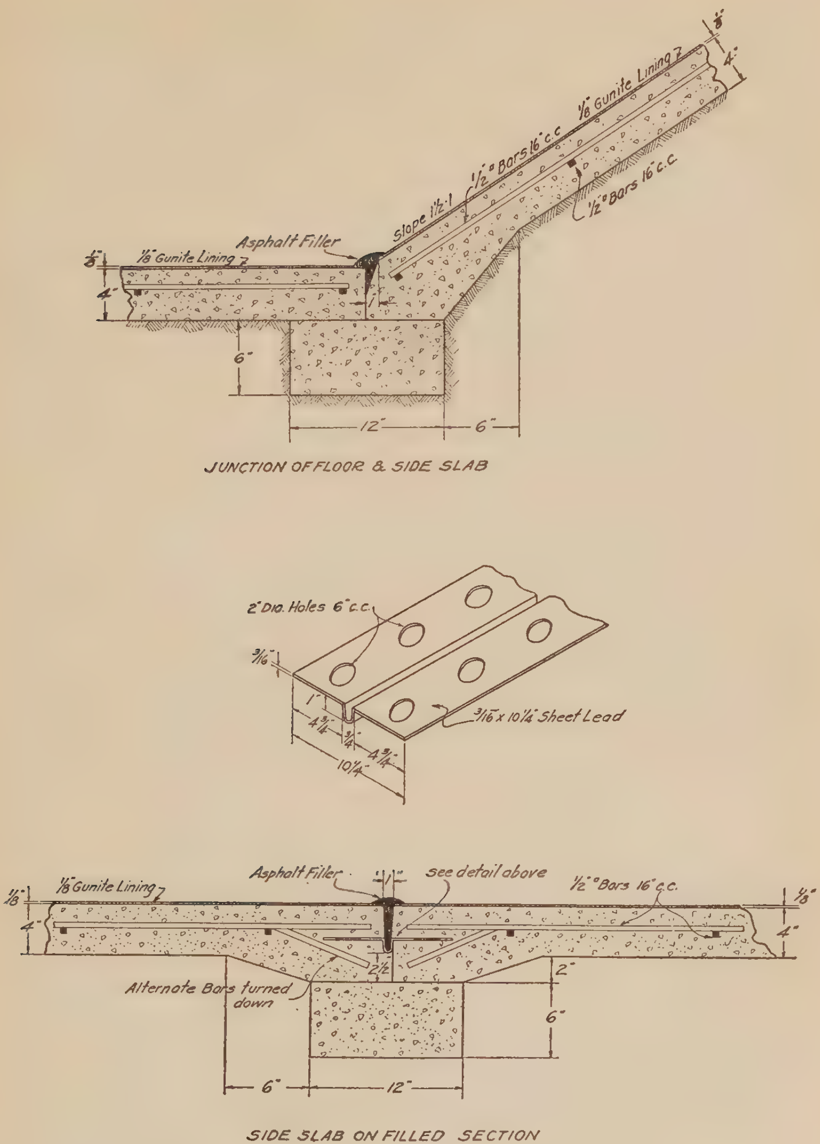
The capacity, type and dimensions of this reservoir are practically the same as Stanford Heights reservoir.

The only important difference is in the concrete lining, the inlet and outlet structures and the overflow spillway, having a capacity of 70 million gallons daily. This reservoir has no division wall.

The reservoir is located about 75 feet north from one of the aqueduct tunnels, which in this particular place was some 5 feet under ground. A shaft was sunk at the point nearest the reservoir and a concrete box built from which a 5-foot by 5-foot inlet tunnel was constructed to the reservoir.

The outlet structure consists of a 4-foot by 4-foot horseshoe culvert under the embankment connecting with the 44-inch pipe line, the outlet flow being controlled by a 4-foot by 4-foot sluice gate at reservoir end of this culvert.

The spillway over the crest of the reservoir is 25 feet long with



EXPANSION JOINTS NILES RESERVOIR
Scale = 3" = 1'

FIG. 3

allowable depth of 3 feet from which an 8-foot by 2-foot concrete chute carries the water 125 feet down a steep hillside to a small creek.

The excavation and fill contract was let in the fall of 1923 and after completion was allowed to stand through the winter of 1923–1924 to allow for settlement of fill before the concrete lining was placed.

The lining is a 4-inch slab of reinforced concrete without expansion joints except at junction of side and bottoms and on the four corners.

The top soil for a depth of 4 inches was stripped and wasted. Fordson tractors and scrapers were used in excavating and transporting the material to the embankment where it was spread in 4-inch layers, wetted, then rolled thoroughly with a Fordson tractor converted into a roller by filling in the wheels with concrete to give it the necessary weight.

The crest of the embankment was carried 6 inches above the required height to allow for settlement. This did not occur as expected and the crest had to be trimmed to grade at a later date.

During the construction of the embankment the concrete outlet culvert was also built.

The excavation and fill contract was completed in three months.

There was 13,000 cubic yards excavation placed in the embankment and 2400 cubic yards of stripped material wasted.

In May, 1924, bids were called for, for trimming, lining and roofing the reservoir. Alternate bids were asked for a 6-inch reinforced concrete lining with expansion joint, or a 4-inch reinforced concrete lining without expansion joints. This 4-inch lining was to be covered with an $\frac{1}{8}$-inch gunite lining.

Ten bids were received ranging from \$28,000 to \$52,000 using the 6-inch lining, and from \$28,000 to \$47,500 using the 4-inch lining with gunite finish. The lowest responsible bidder was given the contract for \$30,419.80.

The lining is 4 inches thick with 0.75 per cent reinforcing, about 0.4 per cent in each direction, consisting of $\frac{1}{2}$-inch bars spaced 16 inches centers. No expansion joints excepting at junction of floor and side walls and on the four corners.

The reinforcing bars were placed continuous throughout the floor and side slabs except where expansion joints occurred. The concrete was then poured in alternate panels of about 20 by 30 feet on the bottom and 13 by 33 feet on the sides.

The mixture was $1:2\frac{1}{2}:3\frac{1}{2}$, with a minimum of 8 per cent hydrated lime. A rather wet, but not sloppy, mixture was used in the floor

slabs; on the side slopes the mixture was made dry enough so that it would stand without forms.

Just before the initial set had taken place small surface cracks appeared. No concern was felt over their appearance, on account of the gunite coating which was to be added. However, they were rubbed out with a wood float and only in a few instances did they reappear. These cracks were probably due to the top of the concrete drying out before the initial set. Thereafter water was applied to the concrete immediately after the initial set and was kept wet ten days after pouring.

After the roof columns were set and the roof completed the cement gun or gunite finish of $\frac{1}{8}$-inch minimum thickness was placed. When finished the coating was nearer $\frac{1}{4}$ inch thick than $\frac{1}{8}$ inch. The gunite mix was one part cement to three parts Marysville sand, screened to eliminate any pea gravel.

A relatively dry consistency was used. The water being added in the cement gun. Air pressure of 50 pounds was supplied at the gun by an air compressor driven by a gasoline engine.

The crew consisted of six men, four men actually operating the plant and two men sweeping up and cleaning away the rebound which amounted to from 10 to 15 per cent of the sand used. This crew was able to cover about 1200 square yards a day. The work was finished in four months' time and the reservoir has been in operation about one year without any trouble.

RAISING UNIVERSITY MOUND RESERVOIR

This reservoir, built in 1885, is located in the southern part of the city at elevation of 165 feet, regulates the supply to practically all the commercial and manufacturing sections of the city. In fact, about one-half of the total supply into the city is regulated from this reservoir.

The crest of the embankment was about 30 feet wide, which would allow a 6-foot fill to be placed on top without making the old embankment any thicker. The total perimeter of the reservoir was 2400 feet of which about 600 feet was excavation and 1800 feet was embankment.

This embankment was raised 6 feet with material borrowed from the adjoining property and transported to the embankment by wagons, when it was spread and rolled in the usual manner, then trimmed and made ready for the concrete lining.

This lining is 2 inches thick with about 0.7 per cent reinforcing consisting of two layers of No. 8 gauge steel wire fabric.

After the embankment was trimmed to the proper grade and the reinforcing in position concrete was placed with a cement gun in about the same manner as on the Niles reservoir.

TABLE 1

Table of costs

	STANFORD HEIGHTS RESERVOIR	NILES RESERVOIR	RAISING UNIVERSITY MOUND RESERVOIR
Capacity, million gallons	5	5	18.4
Total cost, dollars	$68,725.86	$58,850.88	$27,008.25
Cost per million gallons storage	$13,745.00	$11,770.00	$1,468.00
Per cent of total cost			
Stripping	2.7	2.9	
Excavation and fill	22.4	18.8	24.7
Trimming	2.7	4.9	2.7
Lining	31.9	34.0	34.2
Roof	18.7	14.4	
Structures	8.6	12.9	22.9
Division wall	9.9		
Gunite coating		4.9	
Retaining wall			9.6
Engineering	3.1	7.2	5.9
	100.0	100.0	100.0
Other data			
Time to complete	3 months	7 months	4 months
Kind of lining	6″ expansion joints	4″-1/4″ gunite	2″ gunite
Cost of lining per cubic yard	$21.89	$23.67	$47.19
Cost of lining per square foot	42 cents	32 cents	29 cents
Cost of gunite coating, square feet		$4\frac{1}{2}$ cents	
Cost of roof per square foot	27 cents	14 cents	

The full 2 inches was shot at the same time. At the end of each day's run a feather edge construction joint was left on which to start the next day.

An expansion joint was constructed at the junction of the old and new lining.

LAYING CAST IRON MAINS: ORGANIZATION AND METHODS[1]

By Homer V. Knouse[2]

The installation of water and gas mains in the Metropolitan Utilities District of Omaha, Nebraska, is done almost entirely by District forces, the only exception during the past few years being certain lines of 36-inch and 48-inch diameter which were handled by contract. Following the purchase of the water plant by the City of Omaha in 1912, it was found that there was a considerable amount of extension to the distribution system of the water plant necessary, and inasmuch as men trained in laying water pipe were a part of the organization, the installation of water mains by District forces was a natural course of procedure. With the growth of the City, and to meet the increased demands for extension following the war, more gangs were organized by selecting foremen from among the men in the older gangs, and by training caulkers and pipe men under the older foremen. With the acquisition of the gas plant in 1920, still further demands were made upon the Construction Division and the needs were met by the same method of expansion.

Foremen, caulkers, pipemen and a few laborers are considered regular employees of the District, and during the winter or at times of decreased activity, the total number of men employed is decreased by laying off common labor which have been employed on the various gangs. At such times regular employees are employed on inspection, main flushing, repairs and incidental work.

Installation of water and gas mains is a specialized class of work, requiring foremen and skilled labor not generally available in the labor market, and where it is possible to hold together the nucleus of a trained organization from year to year, it seems evident that cheaper and better work can be done than under the contract system where organizations are built up and torn down, not only from year

[1] Presented before the Iowa Section meeting, December 3, 1925.

[2] Construction Engineer, Metropolitan Utilities District, Omaha, Nebraska.

to year but from month to month. Since an organization can be built at the beginning of a season with knowledge of the total amount of work to be done, with the assurance that it can be employed nearly full time, a more efficient personnel will be retained. Under this plan there is always available a considerable number of men for emergency work in the distribution system or at the various plants; the work is more closely under the control of the District and changes in plans are most easily made. Since each foreman is interested in the operation of the system, as well as in its construction, he is in effect an inspector for the District, is on the alert to note changes in the plans which would increase the effectiveness of the work he is installing, and is able to meet difficulties or obstructions which he may encounter of which the Engineering Department had no record or knowledge at the time the plans were made.

A factor greatly affecting the progress and cost of work is a careful planning of the order in which the various jobs shall be done. Moves of machines or gangs should be as short as possible; trench should be opened ready for the gang to begin work; pipe and specials should be on the ground, and the gang foreman should have complete maps in his hands when ready to begin work. Since ditching machines, backfillers and all other special machinery are operated as units separate from the pipe laying gang, and usually serve several gangs, it is necessary that they be routed separately. In general, the plan of work is made with respect to the ability of the ditchers to open trench, and as many gangs as are necessary to keep up with the machine are routed behind the ditcher. Where backfillers, paving breakers, tampers, concrete mixers or other apparatus is necessary, it is ordered to the various jobs so as to keep these machines occupied as nearly as possible full time, and without delaying the other work.

Machines have, of course, displaced a great deal of hand labor, but no new apparatus is purchased until it is clearly demonstrated that a saving can be effected. Ditching machines are used of such size as to handle the work most economically. The backfillers in use are built on a Fordson Tractor, and have demonstrated their ability to refill trench cheaply, and have added advantages in a moving speed of 10 to 12 miles per hour and in being always available for use as tractors with only a few minutes time for removal of boom.

Air compressors are being used to a greater extent each year for

Fig. 1. Danger Signals

Fig. 2. Trench Bulkhead

breaking paving and tamping refilled material, and it is believed their use will continue to increase.

All machines are operated as independent units both in dispatching and in accounting. Items of cost, including depreciation, operating labor, repair labor, repair parts, gasoline, oil and supplies are accounted for and the cost per unit of work done computed, to be used in figuring prices to be applied the following season.

Close contact is maintained at all times between the heads of the division and the foremen in charge of gangs and operators of special machines. Foremen are urged to obtain low cost without sacrificing quality of work, safety of workmen and safety of the public must be given careful attention, every measure must be taken to guard the convenience and good will of the public.

Proper flushing or tamping of trenches must be done if settlement of paving is to be avoided, and the cost of refilling a trench in an unpaved street due to settlement after the construction gang has gone is always too high. In all possibe cases backfilled material is thoroughly flushed, and for this purpose a pipe nozzle 5 feet long is used on the flushing hose. By this means it has been possible to saturate all refill and to eliminate practically all pockets of dry material which might later settle and cause damage. On steep grades it has not only been found difficult to properly flush trenches, but washing out of material during heavy rains causes a large expense. By building timber bulk-heads at intervals of from 50 to 200 feet this trouble has been largely eliminated, and since these bulk-heads may be made of second hand flooring, ship lap or plank the expense is small.

Since all the work of the Construction Division is upon public thoroughfares, the necessity for the protection of the work so that accidents to the public may be avoided is evident. Barricades painted in patterns to afford maximum visibility are provided and are so designed as to be quickly and securely placed, and be conveniently transported from job to job. Provision is made on these barricades for the attaching of red lanterns in such a manner that they will not be easily displaced. Lantern rods are provided with a large metal flag with the word "Danger" thereon, which serves as a warning during the day as well as a support for a red lantern at night. "Slow—Danger" signs are provided to be set back towards approaching traffic in congested districts, and red flags are provided for use on the ends of projecting loads on trucks.

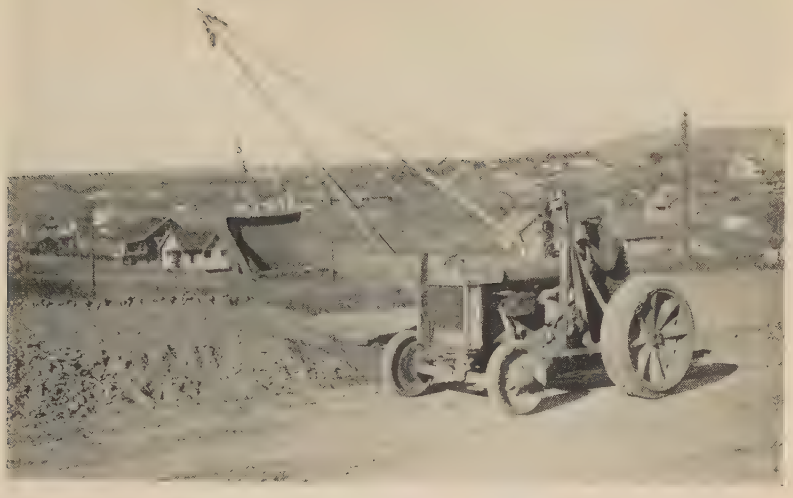


FIG. 3. FORDSON BACKFILLER

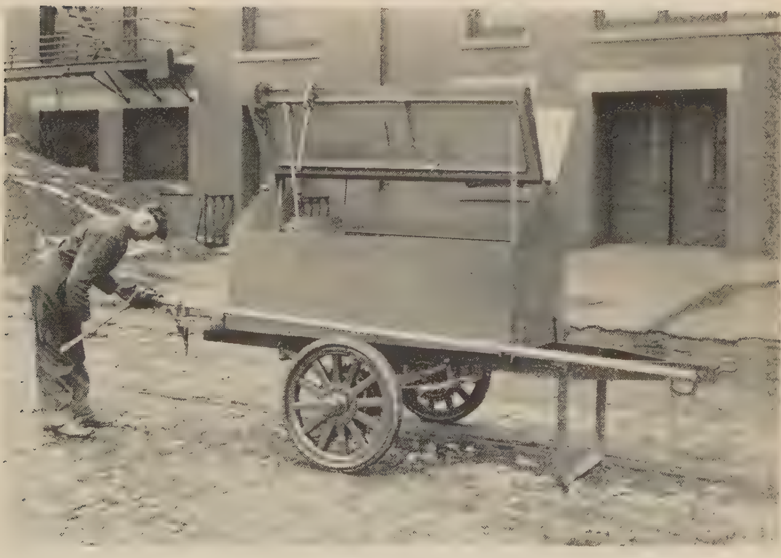


FIG. 4. MAIN TRAILER USED IN INSTALLATIONS OF GAS SERVICES

Fig. 5. Two-ton Truck with "Main Trailer"
Trailer has rubber tires, spring suspended, and steel body

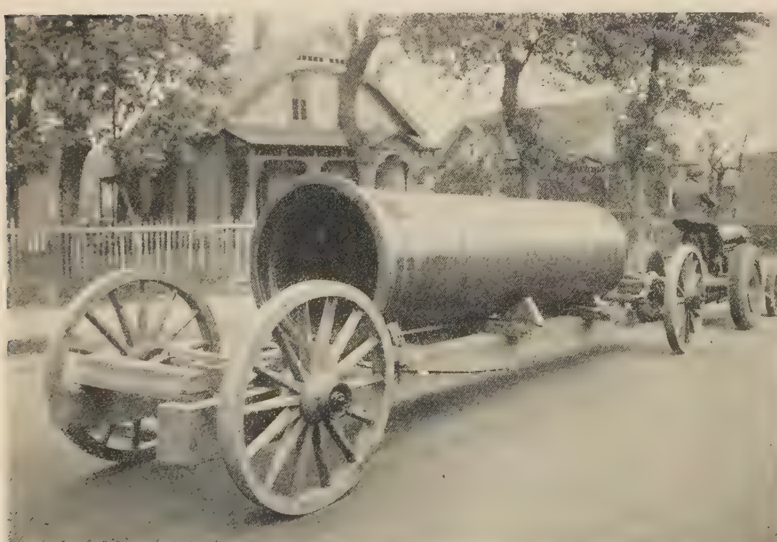


Fig. 6. Horse Drawn Pipe Wagon Used as Trailer Behind Tractor

A rule for the placing of red lamps has been adopted which provides lanterns not more than 5 feet apart on a line at right angles to traffic, 50 feet apart parallel to traffic on main thoroughfares and in a congested district, and 100 feet apart elsewhere. Where necessary to open trenches across streets, care is taken to provide the maximum possible width of crossing and every effort is made to refill such excavation at the earliest possible time. Where trenches are in unpaved streets, a small cheap sign painted yellow and bearing the words "Danger—Soft Trench" is placed at intervals of about 200 feet, and has been found very effective in keeping vehicles out of such trenches. These signs are made from $\frac{3}{8}$-inch boxing lumber with a short piece of lath nailed on for a support, are dipped to give the ground color and then stenciled both sides with the words. The cost is about four cents each, and no effort is made to recover them, it being believed that they will remain in position until the trench is safe.

Upon completion of each job a report is made by the field engineer showing every possible item which might at any time in the future be of interest. The location of every special in the line is noted, distances both from property line and from curb, the location of all structures which may be encountered during the work, such as other water and gas mains, telephone conduits, sewers, etc. are shown on the report which is forwarded to the engineering department for posting on the various office records.

Realizing that special training of all men in the division is necessary, if best results are to be obtained, a foremen's school or conference was started about a year ago for the instruction of foremen and others who have supervisory charge of work. These schools are held Saturday afternoon from 2:00 o'clock to 4:00 o'clock and all foremen are required to attend. Matters are discussed relative to the work, information is given as to what progress has been made during the previous week, foremen describe any particular difficulty they have had in the course of their work and what measures were taken to meet it, and a general training course is carried out. Among the subjects that have been discussed are; best methods of doing various classes of work; safety work affecting workmen and the public; first aid, with particular reference to resuscitation from gas asphyxiation and from shock; procedure in case of an accident either to a workman or the public, such as obtaining names of witnesses and data pertaining to the manner in which the accident

happened; attitude of employees toward the public to promote good will, and numerous other subjects brought up either by the management or the men themselves. As an example, one meeting was devoted to a discussion as to the proper shaping of cutting and caulking tools, the proper size and shape of frost and concrete bars, and as a result of this discussion standards were adopted which have not only simplified the work of the tool department, but have caused much better and more uniform equipment to be sent to the men on the job. These meetings are informal and a general round table discussion by the men interested is obtained. Outside features on various subjects pertaining to the work or to related subjects, suitable moving pictures and steropticon views are contemplated in order to give greater diversity to the meetings and to make them more interesting to the men. While some of these foremen are engaged entirely on gas work, others on water main work, and still others handle both classes of work, it has been found that a splendid cooperation has been brought about and that the time spent is very much worth while.

WATER TREATMENT IN OHIO[1]

By W. H. Dittoe[2]

In 1908, Phillip Burgess, a member of this Section, was retained by the State Board of Health of Ohio to make a study of the then existing filter plants in the State. I am sure he will agree that I am correct in stating that when he made his investigation he found that the plants were generally running themselves, very few of them being in charge of men who knew what they were about. Most of the plants were being operated by men who had not the faintest conception of the chemical reactions involved and bacterial removals which were effected in certain operations and the plants themselves were not what we now consider to be modern filtration plants.

However, Mr. Burgess reported to the State Board of Health that mechanical filtration was an efficient means of producing safe water, if a well designed plant was provided and properly operated. After his work was done there was the inevitable relaxation, which is so customary in State work, a withdrawal of operations and practically no follow-up. In the meantime, these plants continued to operate, and in fact, new plants continued to be built and the problem of producing safe water increased rather than diminished.

As years went by, it was recognized that something must be done to improve the operation of plants. It was not until about six or seven years ago, however, that appropriations were made available whereby a proper personnel could be employed by the State Department of Health. After that was accomplished, competent personnel was employed by the Department of Health, and an energetic campaign was instituted to secure improved operation of the filter plants.

After thorough investigation it was decided that the time had come to insist that the cities of the State employ competent men, specially trained, to operate their filter plants. A program of control of operation of filtration plants was adopted and it was determined to adhere rigidly to that program. The program, while it struck the larger plants forcibly in insisting on full-time technical supervision

[1] Presented before the Central States Section meeting, Dec. 5, 1924.

[2] Chief Engineer, State Department of Health, Columbus, Ohio.

of such plants, also struck the smaller plants with probably equal force, by insisting upon daily analytical determinations, so as to see that the water produced was safe. The proposal was met wth considerable encouragement and support, on the part of municipalities. After a few years effort the majority of the plants in the State were manned by men competent to perform their tasks.

Then came the thought, "here is a group of men working for the cities of the State of Ohio, who are daily gaining information that should be exchanged, disseminated, and be made available." So there came about the organization of these men into what has been called the Ohio Conference on Water Purification.

The Ohio Conference on Water Purification is an organization of men employed by municipalities and water companies in supervision of operation of water purification plants in Ohio. The Conference was formed in November, 1921 at the instigation of the State Department of Health. The purpose of the Conference as set forth in its constitution is "to promote the science and practice of water purification, to promote coöperation among the members of the Conference and with the State Department of Health and in this way to enable each municipality to benefit from the experiences of other municipalities." The active membership of the Conference includes those who are employed in the supervision of operation of water purification plants and also engineers in the employ of the State Department of Health. Engineers engaged in the design of water purification plants and others officially interested in the objects of the Conference are eligible as Associate Members. The personnel of the officers and committees of the Conference is made up from the active membership. While the engineers of the State Department of Health are in close touch with the Conference, it has been the policy thus far to avoid selection of any of the State Department of Health engineers as officers of the Conference or as members of committees. The only exception to this rule is the selection of F. H. Waring, principal assistant engineer of the State Department of Health, as editor of the Annual Report which has been published. Thus the Conference stands on its own feet and while it receives assistance and guidance from the State Department of Health, it is in fact an independent and self-governing body.

Four meetings have been held since the organization of the Conference. Each meeting has occurred in November which month has been considered on the whole to be the most satisfactory. Annual

reports have been published by the State Department of Health and have been given wide distribution. While the greater number has been distributed throughout Ohio, requests have been received and reports have been sent to almost every state in the Union and to many foreign countries.

It may be of interest to mention some of the subjects considered at the meetings of the Conference. Details of laboratory practice and of plant operation were given first consideration. The occurrence and detection of phenol in public water supplies was discussed. Limitations of efficiencies and the corresponding question, limitations of loadings of purification processes, have been discussed. The question of bacterial standard of quality of a filter effluent has been considered. The Conference has also discussed size and quality of sand for filtering material; double coagulation; carbonation and other problems of water softening; corrosion, and the treatment of public water supplies with iodine. One of the most interesting phases of the discussions has been the question box which has developed into a presentation of "tricks of the trade." This has afforded a means of discussing unusual and more or less individual problems demanding initiative and resourcefulness for their solution.

It is perhaps true that Ohio finds a conference of this kind of special or particular value on account of the relative importance of water purification in Ohio. Of a total population of approximately 4,000,000 people served by public water supplies in the state, 3,400,000 are served by water supplies which are purified either by disinfection alone or by filtration plants. There are sixty-four filtration plants serving a population of 2,500,000 and twenty disinfection plants serving a population of 900,000. Of the sixty-four filtration plants, thirty-one have full time technical supervision, twenty-seven have part time technical supervision and six are operated without technical supervision. These six plants are small ones. Of the twenty disinfection plant installations, one receives full time technical supervision. The part time technical superivison referred to is given by the superintendent or chemist-in-charge of a neighboring filtration plant and usually includes daily analytical work with visits at intervals of not more than one month.

Before I speak of the results secured, I would like to mention the personnel of these operators in Ohio. The plants are in charge of thirty-seven different men. Of these thirty-seven, twenty-three are expert operators. They are technically trained men who we felt

could leave their particular plants and go to another plant and make good. They did not have to go through a course of training. In addition to the twenty-three expert operators there are fourteen who may be termed competent. These latter are men who have trained themselves in their particular plants, with the aid of the State Department of Health. So there are thirty-seven men, all of them dependable for their particular job and twenty-three of them fully dependable for almost any kind of a similar job.

There are also plants which are receiving part time supervision, and I would like to call your attention to some of these. For instance, the plants at Ravenna and Tiffin, Ohio, are supervised by the superintendent of the Akron plant. The plants at Conneant, Willoughby and Painesville, are supervised by the superintendent of the Ashtabula plant; the plant at Sebring, by the superintendent; at Alliance; the Upper Sandusky, plant by the Bucyrus superintendent; Barnesville, Delaware, and Woodsfield by the man in charge at Columbus; Wauseon by the man at Defiance; Toronto by the man at East Liverpool; Niles, and Struthers by the man at East Youngstown. Huron, Vermillion, and Wellington, by the man at Lorain. Attica, Cedar Point, and Port Clinton, by the man at Sandusky; Lima, State Hospital and Findlay, by the man at Lima; Napoleon, by the man at Toledo.

This results in a quick service system. In most cases these men are within half an hour of the plants which they are supervising. Each has a Ford machine, or perhaps something better, and telephone communication brings them to the plant in a very short time. An hour will suffice to get them on the job, so that this part time technical supervision really amounts to full time supervision, and would be practically equivalent to full time supervision in a large city.

The results secured from the organization of the Ohio Conference on Water Purification have been satisfactory. The meetings have promoted an acquaintanceship between the members and with the engineering personnel of the State Department of Health and have encouraged coöperation which otherwise would have been difficult to secure. Better plant operation and technique have resulted and better general maintenance of the plants has been realized. Naturally this has resulted in the production of better water for drinking purposes. The existence of the Conference has also assisted greatly in promoting the status of the filtration plant and the plant superin-

tendent in the municipality served. This has brought about a willingness on the part of municipal officials generally to accord to the plant and to the superintedent the coöperation and assistance which is necessary to maintain satisfactory plant operation and efficiency. The Conference appears to be a permanent organization which may be expected in future years to produce even more valuable results than it has produced thus far.

PROGRESS OF THE MELCROFT CASE[1]

By C. A. Emerson, Jr.[2]

The Journal of this Association for June, 1925, carried a rather complete résumé of the Melcroft Coal Case in the report of the Committee on Industrial Wastes in Relation to Water Supply. It is unnecessary, therefore, to consider the early phases of these cases in detail.

Briefly, the Pennsylvania Railroad, the Mountain Water Supply Company, and the Commonwealth of Pennsylvania sought to restrain the Melcroft Coal Company and some twenty other coal companies from polluting a water supply from Indian Creek with drainage from various mines on the water shed. The opinion of the County Court rendered on December 26, 1922, was favorable to the coal companies, but the Pennsylvania Supreme Court, in an opinion rendered on September 29, 1924, reversed the decision of the lower court, concluding that the famous Sanderson cases did not apply, and that because of the public use made of the waters, the coal companies had no right to discharge mine drainage into the stream. The United States Supreme Court declined to review the findings.

In conformity with the opinion of the higher court, an order was issued by the Fayette County Court on January 29, 1925, giving the coal companies until July 30, 1925, to cease discharge of mine drainage into the stream.

Several of the smaller coal companies ceased operation, but certain of the larger companies which continued working their mines endeavored by several methods to comply with the order of the Court. Surveys were run to provide a large drainage ditch for collecting the mine waters and carrying them to a point below the Water Company's dam, but it was found that without the right of eminent domain the cost of acquiring the necessary lands would be prohibitive. Wells were drilled to depths of 200 to 300 feet with the hope of reaching permeable strata into which the mine drainage could be discharged.

[1] Presented before the Central States Section meeting, October 9, 1925.

[2] Consulting Engineer, Fuller and McClintock, New York, N. Y.

These wells soon clogged and became useless. Consideration was given to an underground conduit leading below the dam, to consist of a tunnel through the coal measures and pipe lines where the slope of the coal was such that the tunnel would not conform to the hydraulic gradient. Some of the companies are experimenting with treatment of the mine drainage by sedimentation and addition of hydrated lime.

Shortly before expiration of the period set by the Court, the coal companies petitioned for an extension of time of six months, with permission to later request additional extensions, in order to give them opportunity to devise satisfactory ways and means for compliance with the order of the Court. After argument by attorneys, the County Court dismissed the petition on August 10, 1925.

About the middle of September the Attorney General's Department petitioned the County Court to cite the defendants for contempt, and the hearing on this petition has been set for October 19.

These cases have occasioned a great deal of discussion among waterworks men and particularly those in the coal fields.

All seem agreed that in the case of supplies taken from the larger streams, which for many years have been carriers of mine drainage, little or no benefit will accrue, but as applied to supplies taken from streams where mining operations have been started recently, or where the coal measures have not yet been opened, and where conditions closely resemble those on Indian Creek, everyone is equally agreed that some real, but as yet undetermined benefits will be forthcoming.

There is another side to the problem which has been mentioned but little by the waterworks men, and that is realization of the value of the coal deposits. Coal is so vital to the continued prosperity of the nation that we must recognize that it is not reasonable to believe that the decision of the Court in these cases can be so far reaching as to prevent the mining of sufficient areas to cause great economic loss or permanently interfere with the mining industry at large. This may lead to future legislation that will set up some compromise position. In this event it will plainly be the duty of this and similar associations to use such influence as they possess to prevent legislation that would completely nullify the advantages gained so far through these historic cases.

INCREASING THE CAPACITY OF GROUND WATER SUPPLIES[1]

By W. G. Kirchoffer[2]

This paper deals mainly with water supplies derived from wells, both deep and shallow. For convenience, I have divided the subject matter into eight different headings.

1. WELLS IN ROCK FORMATIONS

These are usually relatively deep and of small diameter.

a. Such supplies especially when there are two or more wells in use can be increased in capacity by reaming out to a larger diameter. Examples of this method were tried out at De Pere and Whitewater with very good results. Coupled with reaming is recasing. Often the old casing has rusted out or never was properly set.

b. Where the distance down to rock is relatively great and it would be expensive, if not hazardous, to attempt to ream the wells they can be shot with dynamite or nitro-jelly in quantities of 5 to 75 pounds.

Shooting does little or no good if not done in a waterbearing formation. That is, if the shooting is done at any depth regardless of the formation, the well may be damaged more than it is improved. During the last four years over sixteen wells have been shot in Wisconsin, mostly city and state wells with some very remarkable results. At Waupun two wells at the Prison and Central State Hospital were shot three to four times with shots varying from 25 to 50 pounds, with the result that the specific capacity of the wells were increased 1000 per cent. At Watertown a well that had been next to useless was shot four times, loosening up about a whole carload of sand and making the well a valuable addition to the city supply. Occasionally the results are not as favorable. A well in

[1] Presented before the Joint Sessions of the Iowa, Illinois and Wisconsin Sections, March 17, 1925.

[2] Sanitary and Hydraulic Engineer, Madison, Wis.

Madison was shot several times in what is known as the Eau Claire formation with the result that each shot only increased the supply about 5 per cent. This was not the fault of the shooting, but because there was no other formation present to shoot. Where detailed records are not available the services of a geologist may assist in determining the proper depth to shoot.

c. It often happens that wells are not drilled deep enough to penetrate all or the best water bearing formations. If there is only one well, it cannot very well be taken out of service to drill it deeper, but where there are several wells this can be done.

At Sun Prairie, Deerfield, Mauston and Tomah, shallow wells have been in use where there was plenty of good waterbearing rock below that could be penetrated. Recently a well at Tomah was put down to a depth of 320 feet and yields as much or more water as the three old 150-foot wells do. It sometimes happens that the quality of the water changes with the depth and that deep seated waters are more highly mineralized than are the waters from shallow wells. On the other hand, some shallow well waters contain much iron which is objectionable from many standpoints. These matters should be taken into consideration before deepening the wells.

d. It used to be and is now a quite common practice to case a well only down to rock and leave the none-waterbearing rock exposed in the well to take water instead of yielding it. This is particularly true where the well is non-flowing, but still penetrates strata that are under pressure. Wells that at one time flowed and have since ceased, have done so principally because the water has escaped in the crevices of the open non-waterbearing rock or if packed, the liner has rusted out.

It is quite a common practice now to drill a well of a somewhat larger diameter down to the water level or to the depth where the water begins to rise in the well and then grout a casing into that level.

e. It is a well known fact that wells if placed too close together will interfere with each other. This is shown by a reduction in the capacity for a definite suction lift or by a greater lowering of water where the quantity pumped is the same. Under ordinary suction lifts wells interfer but little when spaced 400 to 600 feet apart, but if they are pumped by air lift or other means, where the lowering of the water is great, the interference will be relatively large and will be appreciable in the capacity of the system.

Where isolated pumping stations are used and pump directly into the mains, the element of cost does not enter into the consideration of spacing, but where the wells are operated in one system or "gang," discharging into a common reservoir at the station, the economical spacing is dependent not only on capacity, but on the overhead cost of operation due to the greater investment involved for a greater spacing.

2. WELLS IN LOOSE FORMATIONS, BUT RELATIVELY DEEP AND OF SMALL DIAMETER

Such wells are usually drilled or bored and obtain their water through a screen usually of metal. Such screens clog readily with sand and with the mineral compounds deposited by the water. Such supplies can be increased or brought back to their original capacity by:

a. Back-blowing with air, brushing out and washing, a good example of this sort of treatment was at Wausau and the Marathon Paper Mills where the capacities were increased and the suction lift materially reduced.

b. By pulling the screen and replacing it with a new one.

c. By substituting a new gravel packed well, if not too deep.

3. WELLS IN A FINE SAND OVERLAID BY IMPERVIOUS MATERIALS, WATER UNDER PRESSURE SUFFICIENT TO PRODUCE A FLOW OR RAISE THE WATER NEAR THE GROUND LEVEL

It has been customary in this country to treat such formations the same as we do all other sand and gravel waterbearing strata namely use a well screen.

a. In India they make a well called "Mota," meaning cavity. They drill or bore a hole through the impervious materials and case it just to, but not into, the fine sand. They then pump at a high rate until all of the sand that will rise due to that velocity or rate of pumping will come out. This produces a "cavity" under the drill hole in the fine sand, sufficient to supply water at a given rate without drawing sand. The city of New London has a few such wells.

b. This type of well could be modified and greatly increased in capacity by drilling a gang of wells around a large central well

and then applying fine gravel to the outer wells while pumping sand from the central one. This will fill the cavity with gravel and at the same time make a bigger one.

4. WELLS IN SHALLOW FORMATIONS OF LOOSE MATERIALS, SUCH AS SAND AND GRAVEL AND OF RELATIVELY LARGE DIAMETERS

a. Driven wells of small diameter with metal screens. These wells are usually short lived and never should be replaced of same construction, but use some of the other methods hereafter outlined.

b. Tubular wells. These wells are slightly better than the driven wells, for the screen is definitely placed in good water-bearing materials if they exist at the location. This type can be increased in capacity by the back-blowing process or by pulling screen. However, it would be preferable to use some of the more modern type of wells.

c. Wells of relatively large diameter, with gravel packing or strainer about a coarse metal screen. Where a source of supply is now from sand and gravel formations and is inadequate one of the most effective and economical methods of increasing the supply is to use this type of well. There are various methods by which it can be done, but one of the common methods is to sink a large cylinder or casing down through the waterbearing formation, insert a screen with large openings, but of smaller diameter than the bored hole.

The space about the screen is filled with screened washed gravel of proper size for the particular location. When this is down, the larger casing is drawn up to the top of the screen.

Another method is to use a screen with a big shoe attached to the bottom of it of sufficient diameter to carry down a ring of gravel sufficient to properly pack the well. The amount and size of gravel depend upon local conditions of water bearing strata.

d. Another modern method of increasing a supply from loose materials near the surface is to use a circular concrete wall with porous concrete screens set in the side walls. The shoe is made two to four feet larger all around than the outside of the wall. This is sunk by the use of a sand sucker pump, clam shell or orange peel bucket, as the wall sinks the gravel packing is applied to the outside of the wall upon the shoe. A good example of this type of well was

recently put down at Waupaca. The well is 30 feet in internal diameter, 41 feet in external diameter and 30 feet deep. It has a capacity of 900 g.p.m. for a lowering of 8.9 feet. A similar well in coarse gravel formations, but without the shoe or gravel, is the principal source of supply at Delavan.

5. SPRINGS FROM ROCK

Usually deep seated springs must be found not created, as are wells and other types of supply. When they are available they can be greatly increased by creating a large cavity or reservoir about the apparent opening and by so arranging the pumps so that the water level in the reservoir or spring wall can be lowered several feet.

An example of a large spring supply may be found at Lancaster, Wis.

6. SPRINGS OR SEEPS FROM SHALLOW FORMATIONS

These are either from sand and gravel formations overlaid by impervious materials where the water is under pressure and finds its way to the surface or they are at the intersection of the ground water table and the surface of the ground where the water table "outcrops" along some valley.

Such supplies can be increased by applying any of the methods used for shallow loose waterbearing materials or by a porous pipe line laid in washed gravel or by any of the types of infiltration galleries.

7. SUB-SURFACE DAMS ACROSS VALLEYS

a. It often happens that there is an underflow of a small stream at or near the water supply, but in too shallow or too fine a sand to make a water supply by any of the above methods, but if the entire underflow was caught, the supply would be adequate or could be increased by impounding the creek waters back of the dam and causing it to seep into the waterbearing formation below.

An example of this sort of a supply is found in the new supply at Black River Falls where they are building a hollow dam with porous concrete screens in the side walls and a four foot shoe at the sides. The dam is being sunk in sections 16 feet long by 8 feet wide with 4 feet sloping shoe on each side. Upon the shoe or apron,

are placed the rows or layers of coarse sand, roofing gravel and coarse gravel.

The water bearing sand is extremely fine, so a layer of coarse sand is placed next to it, then the roofing gravel and finally the coarse gravel next to the screen. The dam when completed will be 128 feet long by 18 feet 6 inches high. A spillway will be so arranged that the creek can be impounded any depth up to 4 feet which will make quite a lake above the supply. It is estimated that the natural supply from the underflow will be 432,000 gallons per day, but can be increased as the city's needs increase by raising the crest of the spillway.

8. PROSPECTING FOR A NEW ADDITIONAL SUPPLY

What has already been said can readily apply to a case where there is an existing supply, that is, definite knowledge is had of the existence of a ground water source either from previous development or by information supplied from other sources. However, there are cases where the existing supply has never been adequate, although various attempts have been made to increase it. Or there are cases where, for instance, a city has been pumping river water and wants to secure an adequate ground water supply. The question arises what procedure should be taken to secure such a supply.

The procedure now taken in many cases can be divided into three classes.

a. Where the city, under the direction of the superintendent of waterworks, local well driller or college professor, attempts to develop an additional supply without scientific investigation as to quality, quantity or method of development.

b. Where a water supply development company comes in and offers to guarantee a definite quantity of water for a predetermined price. No water, no pay; any water, big pay.

c. Where an engineer or specialist in underground waters is called in to locate a place for the new supply or to direct the prospecting, if it is advisable to do any. Samples of the waterbearing materials are studied for waterbearing qualities and for the probable quality of water they will produce. When a desirable site is found to make a pumping test that will show what the capacity of the formation is to produce water and what type of well is best suited to the local conditions.

Method (*a*) might be the cheapest if the parties are successful in locating a new supply and use proper design and methods of construction, but if they did not, it may be the most expensive, and, as has happened in some cases, a complete failure.

Method (*b*) has this advantage for the city, they do not have to pay for the prospecting work if no supply is found or if the water supply company does not see fit to carry out their part of the contract, because they usually reserve the right to pull out any time they like. If they are successful and carry out the work, it may be expensive for the city. In some such contracts enough attention is not paid to doing the thing legally and to properly protect the city's interest as to quality of water, presence of iron and hardness.

The location and design of the plant are left entirely to the development company which may or may not be a good thing for the city. With this method no adequate competition can be had upon the construction of the plant, as many contractors will bid only on plans and specifications prepared according to law and property adopted by the city authorities.

Under Method (*c*) the city has everything to gain and little to lose. They will have to pay for the prospecting work and for the engineer or water specialist fees. If they select the right man for the place he will find them a supply, even if he has to catch raindrops to do it.

I have known of cases where a water supply engineer had located a supply within a couple of miles of a city simply by his knowledge of the geology of the region and because he knew that water bearing gravels existed usually only on one side of a terminal moraine and on a certain side of the river.

So far we have discussed the source of supply. It often happens that the supply is naturally adequate, but the difficulty lies in the location, elevation or method of pumping. Supplies may be made adequate at least for a time by one or more of the following methods.

a. Substitution of vertical shaft, centrifugal pumps placed in the well so as to effect a greater lowering of the water.

b. Substitution of air lift pumps for other types of pumps or more efficient air lifts for inefficient ones. At Clinton, Wis., shooting of the well and the installation of an efficient air lift for an inefficient one saved the village $1700 per year in their pumping bills.

c. Where suction pumps are used they are often too high above the water so that the pump cannot draw the water in sufficient

quantities. The placing of the pump in a pit or basement often produces the desired result.

d. The substitution of deep well triplex or vertical turbine pumps where a shaft or pit can be sunk will often increase the supply without additional wells.

e. Where the source of supply is from a flowing well or where the water rises nearly to the surface, a reservoir can be added so as to allow the well to flow continuously regardless of the rate or time of pumping.

PROBLEMS OF HARD AND SOFT WATER[1]

By Ross A. Thuma[2]

The question of hard water as a municipal water supply as opposed to that of softened water has been under consideration at the St. Paul water purification plant for more than two years. We have investigated the problem of water softening from many different standpoints, such as, health, plant operation, economy, utility, etc. The purification plant was operated as a softening plant during the month of January, 1925, for the purpose of determining whether it would operate as such. While the period of one month may be too short to form a definite conclusion, our experience was of such nature that we feel confident that the plant would function as a softening plant. Our difficulties were, however, of a different nature, namely, that of convincing the public that softening treatment was worth while. The two questions which seemed to be uppermost in the minds of the citizens were, first, will the softening treatment be in any way injurious to health, and second, will there be sufficient savings to warrant the installation of the softening process? While the value of water softening may be considered from many angles, we shall show that there is no probable danger to the health of the water consumer from the use of softened water, and that the returns on the investment from water softening are, indeed, generous. Furthermore, we shall endeavor to show that water softening is a question of economy and utility, and not a question of heatlh.

WATER SOFTENING IN RELATION TO HEALTH

If one will refer to Water Supply Paper No. 496, United States Geological Survey, by W. D. Collins, he will find the following data. The United States Geological Survey have divided the country into four sections on the basis of the water hardness.

The first division includes the section of the country which has water of a hardness of from 0 to 55 p.p.m. or the soft water area. This territory includes

[1] Presented before the Minnesota Section meeting, November 13, 1925.

[2] Superintendent of Filtration, Bureau of Water, St. Paul, Minn.

the northeastern section of states, New York, the states bordering on the Atlantic and Gulf Coast to Texas and with the exception of Florida, and the states of Oregon and Washington. In this soft water section of the country there are more than 17,000,000 people using soft water.

The second division includes the section of the country which has water of a hardness of from 56 to 100 p.p.m. or the medium soft water area. This territory includes the second tier of states from the Atlantic coast and the states of Montana, Idaho and Nevada. More than 5,000,000 people in these states drink medium soft water.

The third division includes the section of the country which has water of a hardness of from 101 to 200 p.p.m. or medium hard water area. This territory includes the following states; California, Wyoming, Utah, Colorado, New Mexico, Texas, Arkansas, Missouri, Ohio, Michigan, Wisconsin, Minnesota and North Dakota. More than 11,000,000 people in this section drink medium hard water.

The fourth division includes the section of the country which has a water of a hardness of from 201 to 500 p.p.m. or hard water area. This territory includes the states of Arizona, Oklahoma, Kansas, Nebraska, South Dakota, Iowa, Illinois, Indiana and Florida. More than 5,000,000 people drink hard water in this section of the country.

There are then in the United States more than 23,000,000 people who drink water of 0 to 100 p.p.m. hardness with apparently no ill effects. There are more than 16,000,000 million people who drink water of more than 100 p.p.m hardness with no ill effects. We would, therefore, be forced to conclude that the hardness of the water exerts no apparent physiological effect upon the water consumer.

Water softening removes two elements from the water, calcium and magnesium. The body requires for its growth and development about fifteen of the chemical elements. If we must look to our food supply for thirteen of the fifteen chemical elements needed for the upbuilding of the body, why not include the other two in the food requirement? Without going into the details of the matter, we believe that the average diet that will furnish the other elements will furnish, also, the necessary requirement of calcium and magnesium. In view of the above facts, we believe that it is obvious that water ought not to be used for the food elements it contains, but rather as drink.

The taste of water is one of the things which plays an important part in deciding the character of a water supply from the standpoint of the consumer. When one has accustomed himself to drinking water of a given hardness he will dislike the taste of water of a different hardness. A difference in hardness of 25 to 40 p.p.m. is noticeable. In view of the difference in taste due to difference in

hardness, it would seem that the water department would place itself at an advantage by serving water of uniform hardness. The St. Paul water supply varies in hardness from 135 to 225 p.p.m. during the year. By softening the supply to a given hardness, say of from 85 to 100 p.p.m., the objections from change in taste due to change in hardness would be eliminated.

THE COST OF SOFTENING WATER AS DETERMINED AT THE ST. PAUL PLANT

It is a comparatively easy matter to estimate the cost of softening a water of known hardness. The benefits to be derived from such work are particularly difficult to calculate. However, from various estimates derived from the use of soft water, we believe it is well worth while. In this paper we will consider the cost from the viewpoint of increased cost in chemicals. Our working force remains the same whether we soften the water or use aluminium sulfate.

The water during the month of January, 1925, had a hardness of 180 p.p.m. We will base our estimates on the reduction of the hardness to 85 p.p.m. This would require a reduction in hardness of 95 p.p.m. In order to reduce the hardness to the figures given we used lime of 90 per cent available calcium oxide, at the rate of 137 p.p.m. and ferrous sulfate at the rate of 17 p.p.m.

We did not have facilities for recarbonating the softened water for eliminating caustic alkalinity. The caustic alkalinity averaged for the month 27 p.p.m. Recarbonation is necessary in case softening is to be made a continuous process. When recarbonation is practiced there is no danger of after-precipitation of lime on the sand grains, pipe lines, meters, and the alkalinity of the water is under control. We can regulate the reaction of the water within narrow limits to the convenience of the requirements. On the cost of recarbonation we will quote from the experience covering over a period of three years at the Defiance, Ohio, water plant.

For recarbonation of the softened water to eliminate caustic alkalinity, on the average, of 42 p.p.m. and leaving the water charged with 2½ p.p.m. free carbon dioxide as practiced at the Defiance plant. The carbon dioxide is generated from the burning of coke in a small furnace. They figured coke at $12.50 per ton for use in generating the carbon dioxide. The net cost was $1.30 per million gallons of water carbonated.

The permanent hardness of our water supply is too low to require the use of sodium carbonate.

The cost of softening a million gallons as required at the St. Paul plant may then be tabulated as follows:

Cost per million gallons for lime—137 p.p.m. rate of $12.00 per ton f.o.b. plant	$6.59
Cost per million gallons for ferrous sulfate—17 p.p.m., rate $18.40 ton f.o.b. plant	1.32
Recarbonation as at the Defiance plant	1.30
Total cost of softening 1 mil. gals. of water	$9.21

If the cost of treating the same amount of water with aluminium sulfate is deducted from the total cost of softening we would then have the net cost of softening. The cost of treating 1,000,000 gallons of water at the rate of 34 p.p.m. and at the rate of $26.60 per ton f.o.b. plant is $3.80. Deducting this amount from the cost of softening 1,000,000 gallons of water, we have a net cost of softening per million gallons—$5.41.

THE VALUE OR RETURN FROM WATER SOFTENING

The soap saved by the use of softened water is a direct measure of its value. Since the soap consuming power of the water is one of the factors most easily calculated and verified, it will be given first consideration. If we refer to Whipple's formula for soap saved by softening water, we find that for a reduction of 95 p.p.m. hardness, we would decrease the soap requirement of the water equivalent to 21 pounds per thousand gallons. Equivalent to 21,000 pounds per million gallons of water used with soap. Obviously not all of the water softened would be used with soap. We believe, however, that an estimate of 5 per cent of the water softened would not be excessive. This would include water used for laundry, lavatory, dish washing, scrubbing, etc. Figuring soap at 10 cents a pound, which is probably below the average cost, we may then calculate as follows:

21,000 pounds of soap at 10 cents per pound	$2100.00
5 per cent of this amount water used with soap	105.00

Our savings on the cost of soap to the community would be enough to justify the expence of softening the water. To this should be added, also, a utility factor, since soft water is more useful than hard water.

THE SAVING OF FUEL BY SOFTENING A WATER SUPPLY

A great deal has been written and said about the savings in fuel from the use of a softened water for boiler purposes. On this point we have nothing definite. However, an estimate of this saving may be made.

It has been estimated by various authors that a savings of at least 5 per cent may be made by the softening of boiler water supply. S. S. Strout, writing in This Journal (vol. 12, no. 4, 1924) on "Softening of Public Water Supplies" with special reference to San Francisco, declared that 5 per cent of the fuel could be saved by softening the San Francisco water supply. As a basis for comparison and cost estimate we will consider that 5 per cent of the coal used in the City of St. Paul might be saved by softening the water supply. There was used in the city during the year of 1923 about 1,550,000 tons of coal and coke for fuel purposes. If we estimate it at a cost of 10 dollars per ton, we could then calculate that the loss on coal from the use of hard water would be:

75,000 tons of coal @ $10.00 per ton	$750,000.00
On the daily basis	2,050.00

During the year of 1923 the average amount of water used was about 20,500,000 per day or for each 1,000,000 gallons of water—$100.00.

OTHER REASONS FOR SAVINGS FROM SOFTENING WATER

Our experience at the St. Paul plant indicates that a larger amount of water could be filtered when the water is given the softening treatment than when treated with aluminium sulfate. For example, when the water was softened our filters filtered on the average 6,400,000 gallons of water for each filter washed, while during the year of 1924 the average amount of water filtered for each filter washed was 4,076,000 gallons.

In lake water where the algae are apt to be high during the winter months softening treatment has the advantage of precipitating the algae and rendering them less troublesome.

In water high in organic matter, either in a highly dispersed condition or in solution, softening has the advantage of removing more of the organic material and thereby cutting down the chlorine requirement.

By softening and recarbonating the water supply it would be possible to keep the water very near the neutral point and thereby to reduce corrosion to the minimum.

Less frequent shut-down of boilers for repair, less loss from blow off water, less boiler upkeep, less labor and repair, less cleaning of scale, and less cost for boiler compound would also result.

COLON BACTERIA IN SOME FISSURE SPRINGS OF THE BALCONES FAULT ZONE

By I. M. Lewis[1]

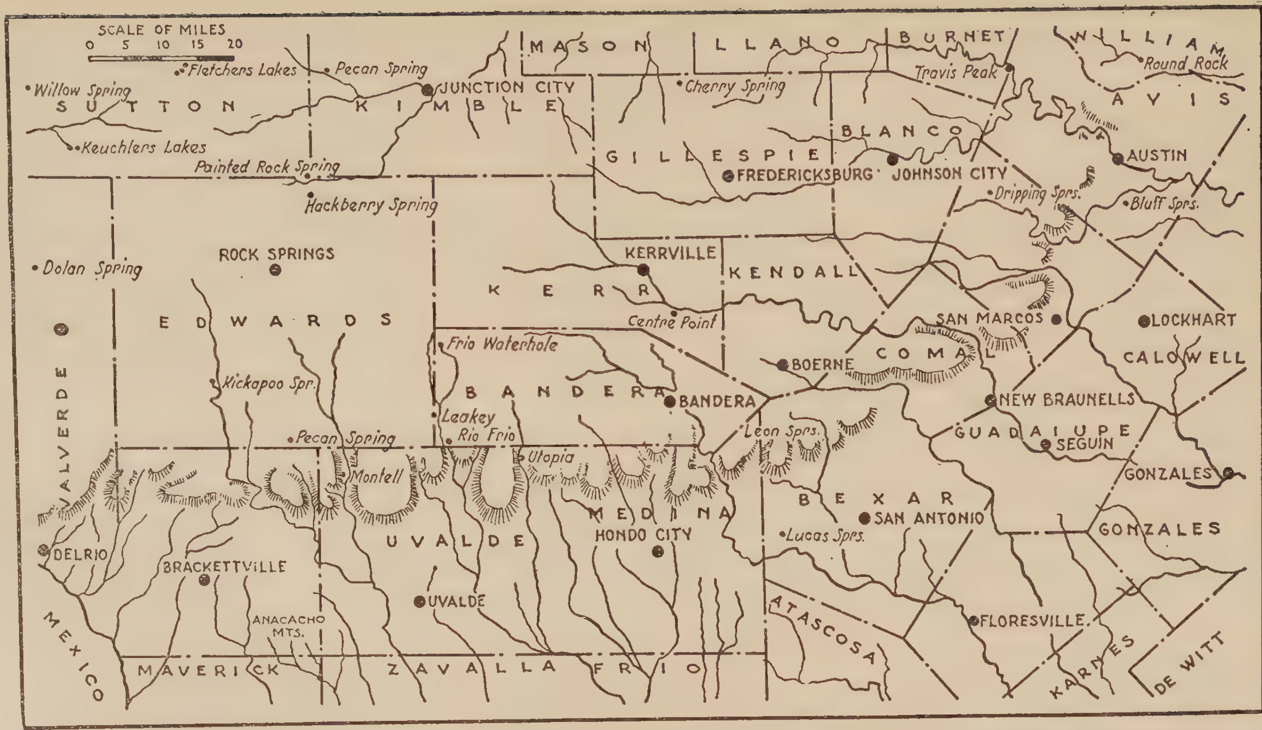
Two of the most important geographic divisions of North America are the Great Plains which occupy the interior of the continent and the broad Coastal Plain which extends along the Atlantic and Gulf Coasts.

To the north, these two divisions are far apart and separated by the Mississippi Valley, the Appalachian Mountains and other geographical provinces. In Texas, the most southerly division of the Great Plains known as the Edwards Plateau and the portion of the Coastal Plain lying farthest west, the Rio Grande Plain, converge and lie side by side. The meeting of these two areas taken place along the Balcones fault line which marks the southern boundary of the Great Plains.

The geology of this region has been extensively studied by Hill and others (2) with special reference to the problem of underground waters. The Balcones scarp zone is easily followed from a point a few miles north of Austin, Texas extending in a generally southwestern direction to a point where it meets the Rio Grande in the vicinity of Del Rio, a distance of over 250 miles. (See map of the area.) The springs in question occur along the northern margin of the plain and coincide almost exactly with the Balcones fault line. Hill points out the fact that these springs are "associated with the system of joints and fractures accompanying the fault line and that their waters come from deep seated rocks and are forced to the surface by hydrostatic pressure. Hence they are artesian in nature and constitute natural artesian wells." He also concludes from a study of the temperature of the water, its similarity in taste, color and chemical content, that "the springs are all of similar origin and that the water is derived from the 'sweet water' horizon of the Edwards limestone or Travis Peak sands."

The temperature of the water, about 71°F., is approximately the

[1] The University of Texas, Austin, Texas.



Map Showing the Relations of the Edwards Plateau, the Balconies Scapr Line, and the Rio Grande Plain

The hachured line is the Balconies escarpment; the Edwards Plateau is to the north of it, and the Rio Grande Plain is to the South.

same as the mean annual temperature of the air in this part of Texas 68° to 69°F. Since normally 50 to 60 feet of depth corresponds to 1 degree change in temperature, it is obvious that the water bearing formation, from which the water comes, can not be located at any great depth below the surface. The great volume of water delivered by these springs and their relative constancy of flow during prolonged drought or heavy rain fall show that their chief source is a formation which transmits water freely and that the reservoir supplying them is vast in extent.

Data as to the daily flow of these springs over an extended period of time are not available. The Division of Hydrography of the United States Geological Survey, however, made measurements of

TABLE 1

Discharge of the various spring rivers

DATE	STREAM (FISSURE SPRINGS)	DISCHARGE IN SECOND FEET	DISCHARGE IN GALLONS IN 24 HOURS
1895			
December 18	Barton Springs	25.0	16,157,921
December 18	Dam Springs, Austin	4.3	2,800,000
December 19	San Marcos	89.0	57,522,200
December 20	Comal	328.0	211,981,932
December 21	San Antonio	42.0	27,145,308
December 21	San Pedro (of San Antonio)	9.0	5,816,852
December 24	Los Moras Spring	21.0	13,572,653
December 24	Del Rio Ditch	19.0	12,280,021
December 24	San Felipe Spring	80.0	57,705,350
	Guadalupe River	48.0	31,023,210

the principal spring rivers during the month of December, 1895. The results are shown in table 1 taken from Bulletin United States Geological Survey, No. 140, page 86. It is safe to say that the average annual flow would not show any very marked variation from these amounts. The question of ultimate source of this water and its sanitary quality has long been a point of interest. A favorite explanation given by inhabitants of the territory in which springs occur is that the water comes from the far distant Rocky Mountains. This explanation has been shown by Hill to be untenable, since the continuity of the strata between these spring rivers and the mountains is completely severed by the valley of the Pecos River. He concludes that the water comes from the Plateau of the plains and its adjacent borders. The area of this catchment

basin is thousands of square miles and its average annual rainfall is 30 to 35 inches per year. Since the nature of the geological formation is limestone, which permits rapid percolation of water through numerous fissures and honeycombed structure, it is obvious that it is capable of supplying vast quantities of underground water. It is also true that much of the run-off water which accumulates in rivers and creeks subsequently disappears at numerous points and adds to the sum total of the ground water.

The sanitary quality of the water has always been considered excellent and it has been used for drinking water, domestic purposes, watering of domestic animals, and in some cases for irrigation. The springs are far-famed for their beauty. The water does not break out from bluffs or fall in cascades as do some of the gravity springs of the plateau country, but rises to the surface forming deep pools which are in reality small lakes of limpid blue water which find their outlets in swift and silently flowing streams.

Barton Springs located at Austin has not been used as a source of municipal supply, but has always been the chief pleasure and swimming resort for the city and surrounding territory. An extensive municipal park has been laid out with modern bath house and the natural beauty has been enhanced by ornamental landscape gardening. The water used in the park is taken from one of the springs and to guard against any dangers to the public health this water is treated by means of liquid chlorine. During the hot summer months thousands of persons visit the springs daily to bathe in the cool invigorating water.

The large group of springs at San Marcos produces a lake more than ½ mile long and of great scenic beauty. The outlet of the lake is the San Marcos River, a beautiful clear stream in which objects may be seen lying on the bottom at a depth of 15 or 20 feet. Aquatic plants frequently grow submerged several feet in the water procuring plenty of light, so transparent is the water. The river furnishes the city water supply, water for the ice factory, for the United States Government fish hatchery and two extensive bathing resorts.

The largest of the springs of this region occurs at New Braunfels and forms the source of the Comal River which flows over 200,000,000 gallons of water per day. One of the numerous springs has been capped and furnishes the municipal water supply.

The springs in the vicinity of San Antonio formerly flowed large volumes of water, but the flow has been somewhat decreased by the sinking of numerous artesian wells to supply the city.

Following the fault line farther west a spring of notable size occurs at Fort Clark, 125 miles west of San Antonio. The last of the series are the San Felipe Springs near Del Rio. Hill says of this spring:

> "From the deep-seated rock at its bottom the water can be seen welling up in a great column, and has the same peculiar greenish-blue color as that of the other springs of this class. No trees surround it; it is alone—a fountain in the desert The outflow from the pool forms a bold, rushing stream that runs off to the Rio Grande some 5 miles distant."

So far as the writer is aware no extensive bacteriological studies have ever been published on the waters from these springs. It has not been possible in the present investigation to procure samples from all of them in sufficient numbers to establish conclusive results for the entire series. However, the analyses of water from Barton Springs at Austin have been carried out over an extended period of time, and the data obtained are sufficient to warrant definite conclusions as to its purity, based on methods now employed in the standard methods of water analysis and the standards set by the United States Treasury Department.

During the past ten years, the water of Barton Springs has been analyzed numerous times by students in the bacteriology classes of the University of Texas. These analyses have always shown that the water has a very low bacterial count, rarely reaching as many as one hundred bacteria per cubic centimeter when grown on plain extract agar at 37°C. As to the presence of lactose fermenting bacteria, the results have been variable, but more often the samples have been positive and members of the colon group have been isolated on many occasions. During the past year, a more extensive investigation has been carried out on the water of this group of springs than had heretofore been made.

Samples were collected daily for a period of thirty days from each of the three principal outflows of the Barton series. These samples were analyzed immediately after collection. The samples were taken in sterile glass stoppered bottles at points where the water rushes up out of the rock fissures. There is no possible source of surface pollution at these points. Total plate counts were made from each sample on plain extract agar incubated twenty-four hours at 37°C. Fermentation tubes of lactose peptone broth were inoculated with five 10-cc. portions of each sample and incubated twenty-four to forty-eight hours at a temperature at 37°C.

From each of the positive fermentation tubes inoculations were made to Endo agar using the modified formula of Levine (3) except that Witte's or Merck's peptone was used. The fermentation tubes were well shaken and one loopful of the broth was streaked over the surface of the plate. By this method numerous well isolated colonies were obtained on at least one half of each plate.

The Endo plates, when positive, were very characteristic. The diffusion of the red color is not marked on the part of the plate where the colonies are well separated. The colonies are luxuriant and have a red halo around them within eighteen hours. On this medium, it is not difficult to distinguish the Escherichia section of the group from the Aerobacter section with a high degree of certainty. Escherichia colonies are not so large; they differ in elevation, being

TABLE 2

Results from three of the Barton Springs, Austin, Texas, from daily samples for a period of thirty days

SPRING NUMBER	SAMPLES TESTED	AVERAGE PLATE COUNT	POSITIVE FERMENTATION TUBES OUT OF 150	POSITIVE ON ENDO AGAR	ESTIMATED ESCHERICHIA COLONIES	ESTIMATED AEROBACTER COLONIES	CULTURES ISOLATED	PER CENT ESCHERICHIA	PER CENT AEROBACTER
1	30	25	114	97	85%	15%	50	79	20.3
2	30	26	111	93	80	20	51	78	21.4
3	30	27	118	98	85	15	53		20.4

more flat and they soon develop a beautiful metallic sheen which is not present on the colonies of Aerobacter. All positive Endo plates were carefully examined to determine the relative numbers of these two types of colon colonies. It became evident, after a few samples had been tested, that the Escherichia type is much more common in these samples than the Aerobacter type. This finding was later confirmed by a study of cultures isolated from the plates. Many of the plates produced only colonies of the typical Escherichia type, while others showed both types of colonies. There were also occasional colorless or pinkish colonies which proved to be non-lactose fermenters and some of the Endo plates failed to develop any colon colonies. In no case did the colonies of the Aerobacter type predominate.

Cultures were isolated to plain agar slants. Not more than one culture of each type was isolated from any one plate, and not more than two from each sample. After growth on the plain agar slants all cultures were re-streaked on agar plates and single well isolated colonies were then fished again to plain agar slants. So far as could be ascertained by means of the Gram stain all cultures employed in the subsequent differential culture work were pure cultures.

The cultures thus isolated were tested as to their ability to ferment lactose with formation of both acid and gas. A total of 154 such cultures were obtained. These cultures were separated into two groups by means of the Voges Proskauer and methyl red test, using the medium of Clark and Lubs and an incubation period of five days at 30°C. As was predicted from a study of the colony characteristics, the Escherichia group predominated over the Aerobacter group. There was a surprisingly high percentage of correlation between the two reactions. Very great care had been exercised to insure purity of the cultures which according to the results of others is an important factor in the correlation. Of 154 cultures tested, 32 cultures or 20.7 per cent gave a positive test for acetyl methyl carbinol. The cultures which were positive in this test were negative in the methyl red test with two exceptions. These two were positive in both tests. The Voges-Proskauer positive colonies all fermented sucrose and glycerine with both acid and gas and are, therefore, classified as belonging to Aerobacter aerogenes. The remaining 122 cultures were grown in sucrose for further separation of the group. Of 122 cultures tested in this sugar 75 were positive. Some difficulty was experienced in definitely placing these sucrose positive organisms. When tested for motility and cultured in salicin, there was considerable discrepancy in the results as recorded. Many of the organisms of undoubted motility failed to ferment salicin with formation of either acid or gas.

Classing all motile sucrose fermenters as Escherichia communior, 69 cultures or 57 per cent of the Escherichia section, 44.8 per cent of all cultures, belong to this species. The remaining sucrose fermenters, 4 per cent which were non-motile were further differentiated by means of salicin fermentation. The cultures which did not ferment sucrose were differentiated by growing in salicin. All positive cultures are classed as E. coli, negative as E. acidi lactici. There were 19 per cent of the cultures in this group which belong to the species E. acidi lactici and 11 per cent which belong to the species E. coli.

It is obvious that this classification does not bring out the variants of the group, but this was not deemed essential in this particular case since the primary object was to determine the incidence of the two main divisions. It is well known that as additional tests are applied the group can be broken up into many different types. As classified by this more simple grouping the results may be summarized as follows:

Total cultures	154
Aerobacter section	32 or 20.7 per cent
Escherichia	122 or 79.3 per cent

The distribution by species follows: Aerobacter, 20.7 per cent; E. communior, 44.8 per cent; E. pseudocoscoroba, 4 per cent; E. coli, 11 per cent; E. acidi lactici, 19 per cent.

DISCUSSION OF RESULTS

The results of this investigation are somewhat surprising, in that it would seem logical to expect a higher percentage of the Aerobacter section of the colon group in waters of this quality. There are not, however, many data at hand with which to compare these results and the results of others on similar waters. The work which most nearly approaches it and to which the results may be most appropriately compared is that of Winslow and Cohen (8). These workers isolated colon bacteria from waters of known sanitary quality in the vicinity of New Haven and found that the percentage of Voges Proskauer positive organisms did not differ markedly in polluted, unpolluted and stored waters. The percentage of Aerogenes strains was moreover about the same in the stored waters as has been found in the present case.

These results also approximate very closely the findings of Elinor Rogers Houston on some ground and surface waters in the vicinity of Austin, Texas. This investigator during the season of 1923 studied the incidence of colon bacteria in 91 samples of water. These samples were obtained from a variety of sources which may be divided into two groups on the basis of probable pollution. The first of these consists of 23 samples where pollution might have occurred and the remaining 58 were from sources not polluted, so far as could be determined. These samples might also be grouped according to the kind of source, as follows: 32 from shallow wells, 35 from springs, 8 from small streams, 4 from the Colorado River, 4 from

pits dug in the sand several feet from the rivers edge, 3 from the city tap water, 3 from tanks and 2 from deep wells. In testing these samples, 23 proved to be negative for lactose fermenters. From the remaining sample 154 cultures were isolated. These cultures were grouped as follows:

Aerobacter section	6.3 per cent
Escherichia section	93.5 per cent

The chief numbers of the Escherichia type occurred in the following order: E. communior, 25.3 per cent; E. acidi lactici, 25.3 per cent; E. coli, 11.6 per cent; E. pseudocoscoroba, 5.2 per cent; E. neapolitanum, 2 per cent, while the remainder were atypical in one or more characteristics.

It is impossible from the above results to conclude that the Aerobacter section of the colon group is present in any great numbers in any of these waters. On the other hand Rogers (5), Stokes (6) and Wood (9) have reported conditions which are quite the reverse, and which would seem to be difficult to reconcile. As a result of their investigation of the New Haven waters, Winslow and Cohen reach the conclusion that the significance of the ratio of Bact. coli and Bact. aerogenes group in a sanitary examination of water would have little significance, in case results similar to theirs were obtained in other regions.

A matter which merits discussion in interpreting the present results is the viability of these types in water. It has been demonstrated by the experiments of Rogers (4) that Aerobacter does not die off nearly as rapidly as the Escherichia type when stored in water bottles, or in parchment bags in running streams. The work of Winslow and Cohen (7) gave similar results. There seems little doubt therefore that the Aerogenes type will persist longer in water under natural conditions than Escherichia.

How, then, are we to account for the overwhelming predominance of the Escherichia type in these deep fissure springs in which the total bacterial content is extremely low and where the water doubtless travels underground for a considerable distance and which during dry periods could not possibly be recently polluted from the surface? There seems to be but one approach to this problem. The explanation must be sought through a study of the catchment area which furnishes the water and from which it obtains its pollution. The catchment area is vast in extent and is made up prin-

cipally of the Edwards limestone of the Plateau of the Plains, and the outcrop of the Glen Rose formation and Travis Peak sands, which occur along its western borders. The rain water which falls on the Edwards Plateau percolates downward through the limestone itself to the water bearing strata. This percolation is frequently hastened and the water reaches the embed through intricate conduits from the surface such as fissures and caves and honeycombed spaces in the limestone area. These caverns facilitate both the vertical and horizontal movements of the water. Throughout this limestone region there are found numerous underground passages, some of which are quite large in extent. Such cavities have been frequently penetrated by drill holes in the vicinity of San Marcos and San Antonio. Another factor which must be taken into account in attempting to interpret the results of the bacterial content of these waters is the extent of population which occupies the section of the Plateau from which the water comes. This is a rough and rugged country with rocky soil, not suitable to extensive development of agriculture and supports only a very limited human population. It is chiefly grazing country and there are many large sheep, cattle and goat ranches. It is evident, therefore, that such pollution as finds its way into the percolating water is derived from animal sources rather than from cultivated soils or human sources. The bacteria belonging to the colon group are doubtless very abundant at the time of the initial pollution and are predominantly of the types typical of animal feces. That E. communior is the predominating type is not therefore to be considered strange. It also seems that any interpretation of the relative incidence of the type of colon bacteria in water should take into account the local conditions which affect it.

SUMMARY AND CONCLUSIONS

The water which supplies the chain of "sweet water" springs alone the line of the Balcones escarpment has its source in the vast plain of the Edwards Plateau and the outcrops of the Glen Rose formation.

The springs are fissure springs, natural artesian wells, which come from a water-bearing stratum located only a few hundred feet below the surface. The water rises due to hydrostatic pressure.

The nature of the limestone formation of the Plateau facilitates rapid movement of the water both vertically and horizontally.

The predominant type of the colon group, as determined by examination of Endo plates and the study of 154 cultures, is the Escherichia type rather than the Aerobacter type.

The nature of the catchment area is such that the surface pollution is from animal feces rather than cultivated soil or human sources.

Escherichia communior is the predominant type present in these waters. The presence of colon bacteria of the Escherichia type in these waters is not of such great sanitary significance as would be the case if the catchment area supported a more numerous human population.

REFERENCES

(1) Greenfield, Myrtle 1916 The presence of soil and fecal strains of organisms of the colon-aerogenes group in the water of Kansas. Jour. Inf. Dis., xix, 647–651.

(2) Hill, Robert T., and Vaughan, T. Wayland 1896 Geology of the Edwards Plateau and Rio Grande Plain adjacent to Austin and San Antonio, Texas, with reference to the occurrence of underground waters. Eighteenth Annual Report, United States Geological Survey, Part II, 193–321.

(3) Levine, Max 1921 Bacteria fermenting lactose and their significance in water analysis. Iowa State College of Agriculture and Mechanic Arts, Official Publication, vol. xx, no. 31.

(4) Rogers, L. A. 1917 The viability of colon-aerogenes bacteria in water. Abst. Bact., 59.

(5) Rogers, L. A. 1918 The ocurrence of different types of the colon-aerogenes group in water. Jour. Bact., iii, 313–328.

(6) Stokes, W. R. 1919 The presence of fecal and non-fecal types of the colon bacillus in various types of water. Amer. Jour. Pub. Health, ix, 571–74.

(7) Winslow, C. E. A., and Cohen, Barnett 1918 The relative viability of B. coli and B. aerogenes types in water. Jour. Infec. Dis., xxiii, 82–87.

(8) Winslow, C. E. A., and Cohen, Barnett 1918 The distribution of B. coli and B. aerogenes types in polluted and unpolluted water, Jour. Infec. Dis., xxiii, 90–101.

(9) Wood, D. R. 1919 Studies in the bacteriology of water. Inst. of Water Engineers, London.

NITRATE DETERMINATIONS[1]

By Geo. W. Burke[2]

The method for the quantitative estimation of nitrate nitrogen in water and sewage as given in "Standard Methods of Water Analysis," specifies that the residue from evaporation of the sample be moistened with 2 cc. of phenoldisulphonic acid, diluted, neutralized, and finally made up to 50 cc. in a Nessler tube in readiness for comparing with standards.

It has been observed that the color imparted by adding 2 cc. of phenoldisulphonic acid to sufficient nitrate-free water and alkali to neutralize and bring the volume up to 50 cc. is sufficient to lead one to believe that considerable nitrate is present. This color is somewhat brownish in appearance and darker than the true color produced by making alkaline the small amounts of the nitrate standard solution contained in the standard Nessler tubes. Under these conditions it is quite impossible to make use of a blank determination to offset this coloration. It has been found that, if the same amount of phenoldisulphonic acid (1 cc. is sufficient), is added to each of the Nessler tubes containing the standards as was used to moisten the evaporated residue of the sample, a condition will be brought about wherein similar shades will be obtained. The sample can now be accurately matched by one of the standards.

When dealing with samples of sewage containing considerable organic matter of such a nature that it cannot be eliminated by filtration, clarification, etc., it has been found that the phenoldisulphonic acid method cannot be employed due to the darkening effect produced by the action of the strong acid upon the organic matter. Under such circumstances it is necessary to resort to the reduction method.

In the reduction method the sample, freed from ammonia, that is, introduced into the tube for reduction, contains all the nitrite and nitrate nitrogen which is reduced to ammonia. Due to the fact that

[1] Presented before the Iowa Section meeting, November 6, 1924.

[2] Engineering Experiment Station, Iowa State College, Ames, Ia.

the nitrite value (otherwise determined), has to be subtracted from the nitrite plus nitrate value obtained by nesslerization, it is necessary to know accurately the value of the nitrite standard solution in terms of the ammonia standards. This is best determined by reducing a sample of the nitrite standard solution and obtaining its value in exactly the same manner as the reduction method is carried out. A blank should be employed in this connection. Having the nitrite solution standardized in this manner the proper deduction can be made to secure the correct value for the nitrate content of the sample.

As to the distillation of the reduced sample, a good practice is to boil a sufficient amount of slightly alkaline distilled water, on the condensing apparatus, until the distillate is free from ammonia. When such a condition is brought about the water is cooled, and the sample is added and distilled, the distillate being caught in a 250 cc. graduated flask. After the flask has filled with distillate it is shaken up and an aliquot is nesslerized.

USE OF CHINIC ACID IN THE DIFFERENTIATION OF THE COLON-AEROGENES GROUPS[1]

By B. H. Butcher[2]

In 1911, Beijernick called attention to the fact that some strains of Bact. aerogenes produce a red to black coloration in a medium containing chinic acid and a ferric salt, this taking place under aerobic conditions. Strains of Bact. coli, he says, do not color the medium under similar conditions. In such a medium, under anaerobic conditions a fermentation may occur with some members of the aerogenes group in which carbonic, acetic and propionic acids are formed. An attempt was made by the writer to duplicate this anaerobic type of fermentation by organisms of the colon aerogenes group, but without success. Both Smith and Durham tubes were used, but no carbon dioxide was detected. However, the coloration produced by Bact. aerogenes when it grows on chinate medium under aerobic conditions was found to be pronounced. The color produced is soluble and diffuses through the medium in both solid and liquid. It was thought that this observation of Beijernick might be used as a possible differential test for colon-aerogenes strains.

The laboratory tests usually employed for the differentiation of the coli and aerogenes sections are the Voges Proskauer and the methyl red reactions. Both of these are classified as color reactions and require a medium consisting of dextrose, peptone and phosphate. There are other tests which may be considered supplementary to the Voges Proskauer and methyl red reactions. Thus, in considering the coli sections the gas ratio CO_2/H_2 is nearly 1:1 and indol usually positive. The aerogenes section shows a gas ration CO_2/H_2 of 2:1 and indol usually negative. Another interesting differential test is that of Koser (1922). He states that Bact. aerogenes will produce abundant growth in a medium in which a sodium, potassium or ammonium salt of citric acid is the sole source of carbon. The citric acid medium will not support the growth of Bact. coli.

[1] Presented before the Iowa Section meeting, November 6, 1924.

[2] Department of Bacteriology and Agricultural Experiment Station, Ames, Iowa.

This work on the chinic acid medium and its coloration was begun with the belief that it might prove to be a useful test which could be used in connection with the various differential tests just mentioned. The medium used is as follows:

H_2O	1000 cc.
K_2HPO_4	0.5 gram
NH_4Cl or peptone	0.5 gram
$FeCl_3$	0.1 gram
Calcium chinate	10.0 grams

Chinic acid is in chemical terms, hexa-hydro-tetra-oxy benzoic acid. The calcium salt is made by neutralization with CaO. The minimum quantity of the calcium salt to be used is 0.5 to 1 per cent. It has been found preferable to inoculate agar agar slants or plates rather than a liquid medium, since the coloration in case of Bact. aerogenes is due to an oxidizing action. Di-hydroxy-benzoic acid is an oxidation product of chinic acid. This di-hydroxy-acid is responsible for the dark coloration with a ferric salt present. Obviously more favorable aerobic conditions are obtained on the surface of solid than in liquid cultures. After inoculation the chinate medium is incubated at 37° and within twenty-four hours some strains of Bact. aerogenes produce a distinctly dark color on the surface of slants or plates and the color soon diffuses. Other strains which do not give a distinctly positive Voges Proskauer reaction require three or four days of incubation to develop a pronounced coloration.

A total of forty-three known organisms were tested on the chinate medium. Eighteen of them were members of the aerogenes section. Of these eighteen there were six belonging to the species Bact. aerogenes, five to the species Bact. oxytocum, six were Bact. cloacae, and two were Bact. levans. The Bact. aerogenes and Bact. oxytocum organisms checked with the Voges Proskauer reaction. The Bact. cloacae, and Bact. levans tried produced no coloration in chinate medium. This observation indicates the possibility of using the test to differentiate organisms even within the aerogenes group as well as between the coli and aerogenes groups. Of the twenty-three strains of the coli section tested, none gave any coloration to the chinate medium as table 1 shows.

It was thought that, since the coloration produced in the chinate medium by organisms is a result of an oxidizing enzyme, the addition of a source of oxygen to the medium in the form of nitrate might

hasten the appearance of the dark color, but the nitrate had no appreciable effect.

A stock medium containing 1 per cent of calcium chinate may be preserved for many weeks without any coloration resulting from oxidation by the air. This is true even at 37° especially if a solid medium is being preserved.

TABLE 1

		Voges-Proskauer	Methyl red	Gelatin	Motility	Glycerol	Coloration on chinate medium
Aerogenes section	Bact. aerogenes (6 strains)	+	−	−	−	+	+
	Bact. oxytocum (5 strains)	+	−	−	−	+	+
	Bact. cloacae (6 strains)	+	−	+	+	−	−
	Bact. levans (2 strains)	+	−	+	+	−	−
Coli section	Bact. coli (6 strains)	−	+				−
	Bact. communior (1 strain)	−	+				−
	Bact. coscorba (2 strains)	−	+				−
	Bact. grunthali (6 strains)	−	+				−
	Bact. pseudo coloides (1 strain)	−	+				−
	Bact. schafferi (4 strains)	−	+				−
	Bact. neopolitanum (2 strains)	−	+				−
	Bact. Vesiculosium (1 strain)	−	+				−

In summation, it may be said that the chinic acid test agrees well with other differential tests of the colon-aerogenes group and it should prove a convenient and valuable method to be used in species identification.

REFERENCES

Beijerinck 1911 Pigments as products of oxidation by bacterial action. Proc. Soc. Sci., Kan. Academy Voss Wetenschappen, Amsterdam, vol. xiii, p. 1066–1077. (Reprint, Beijerinck, Verzamelde Geschriften, vol. 5, 1911, p. 1–10.)

Koser 1923 Utilization of the salts of organic acids by the colon-aerogenes group. Jour. Bact., 7, p. 493–520.

Leonard Metcalf

Born at Galveston, Tex., August 26, 1870
Died at Concord, Mass., January 29, 1926

In our JOURNAL for December, 1925, there is a characteristic contribution from Leonard Metcalf, on "Price Trends upon Centrifugal Pumps." It was written while he was dying of cancer of the stomach at his home in Concord, Mass., but nowhere in it is there any indication of his knowledge that it was probably the last thing he would ever be able to do for our Association, whose welfare had been so close to his heart for many years. At the Louisville Convention, a very few of his intimates knew that this dread disease had laid its fatal hands on him, but nothing he did or said there gave any inkling that he was aware it was probably the last meeting he would attend. That was his attitude throughout the whole of his long illness. He accepted the inevitable without comment, and worked as well as his slowly failing strength permitted to the very end, without complaint, efficiently and logically as ever.

Ever since he joined our Association in 1903 he took a deep interest and active part in its work. He contributed numerous papers, took part in many discussions and in the investigations of several important committees, and served as our President in 1916–1917. He cordially coöperated in establishing our Council on Standardization and was one of the advisers of Mr. Little, then President, in appointing the first members of that body. His interest in its work never flagged and he was the largest individual contributor of material to its "Manual of American Water Works Practice," most of these contributions being made after he knew that the remaining span of his days was brief.

In his work for our Association the characteristic of thoroughness which marked everything he did was fully shown. In fact, his last word to us, in the article in the December JOURNAL, is a rounding-out of an earlier contribution to the "Manual" and contains data that will long prove of value to those making valuations of water works.

This thoroughness not only covered technical matters but business affairs as well. His unusually wide range of interests made him for many years a trusted, valued adviser of owners of public utilities as well as of trustees of municipal plants. At one time he operated a number of water and electric plants for their owners. In business as in engineering, there are often several ways of accomplishing a given object, and the choice between them can be made safely when the details of each way are fully understood. His thoroughness rendered his advice particularly useful in solving such problems, and for years he held the reputation of a man who was familiar with the details of all procedures but had no favorites among them, using in each case that which was best suited for the conditions of it.

He began his practice as a consulting engineer in 1897 and in 1907 he joined Harrison P. Eddy in establishing the firm of Metcalf & Eddy. Early in his consulting practice he was engaged in legal cases involving valuations of water works for rate making and for sale, and until his death this class of work occupied much of his personal time. He was unusually successful in it and made a deep impression upon courts and public utility commissions before which he testified. This may be indicated by a letter sent to one of the partners in his firm by Hon. Charles E. Gurney, chairman of the Public Utilities Commission, after he learned of the fatal illness of Mr. Metcalf:

> Among the emoluments of my present position, more attractive to me than the financial return, are some of the men I have met, whose lives and achievements inspired my admiration and an endeavor to do my best work each day. None of them has impressed me more deeply for qualities of character, a manifest integrity and a steadying earnestness of purpose than Mr. Leonard Metcalf, of your firm. I always felt as he testified before this Commission that there was no danger of his stultifying himself by making any statement in which he himself did not place implicit confidence. I felt that he would not exaggerate wantonly and that I could depend upon what he told me. I do not mean by this that I closed my own mind and accepted his word as infallible, but I do mean I felt that so far as human error honestly made might be excluded, Mr. Metcalf's word might be accepted and that he would not sell his opinion to the highest bidder.

When the American Society of Civil Engineers undertook the great task of clearing away the tangle in which the engineering features of valuation work had become involved, he was appointed a member and secretary of its Committee on Valuation. Upon him fell a very laborious task, which he executed patiently, carefully

and with great tact. It is not belittling the services of the other members of this Committee to say that no small part of the credit for the successful outcome of its investigations was due to him. As commissions and courts continue to deal with this subject, it is interesting to observe the steady trend of their decisions toward those views which he advocated consistently. His reputation as an authority on the subject will continue to grow and the indebtedness we owe to him for his pioneer work in behalf of justice and equity in such matters will be better understood in the future than it is now.

In the Spring of 1917 he was appointed a member of an advisory committee to the sub-committee on Emergency Construction of Buildings and Engineering Structures of the Council of National Defense. The other members were George W. Fuller and Asa E. Phillips. It was largely through their efforts that civilian experts were obtained so promptly to carry on the construction of camps and cantonments and the apparently impossible task of having quarters ready for the first draft when it arrived was accomplished. In this work Mr. Metcalf's wide knowledge of engineers and contractors, his fearlessness and above all his judicial temperament made his services invaluable. When the work was finished he returned to his practice, but not before he volunteered his services to the Chief of Engineers for overseas duty of any kind for which his experience fitted him. The personnel division of the army realized, however, that he was more useful in his civilian life than in any of the subordinate posts in the A. E. F. which were then unfilled and this offer was not accepted.

He was an excellent business man, as was to be expected from his logical mind, tactful manner, and fearlessness. But he was also a very human individual, quick to see the humor of a situation and wholly without sensitiveness about the fact that sometimes he caused the humor of an incident. He had a personal experience he occasionally told, with much amusement at his own part in it, to persons who expressed regret that masses of men are sometimes swayed by emotion rather than logic. He was much interested in public affairs in his home town of Concord, and at a meeting there one evening he thought he noticed a trend toward a conclusion justified neither by facts nor logic. So he closed the discussion by what he considered a very clear explanation of valid reasons for making a certain decision Then a vote was taken in which he was the only supporter of his plan, the rest of the audience voting solidly for what he op-

posed. This defeat of logic caused him only amusement, for he had done his duty as he saw it and if others did not agree with him he realized they should vote as they thought. This was characteristic of his attitude during some of the old controversies in our Association. There was nothing of personal prejudice about them, so far as he was concerned, and he acted always as he thought best for the Association's welfare.

His dignified carriage and speech immediately told those who met him for the first time that he was a truly learned man. He was graduated from the Massachusetts Institute of Technology in 1892 and deeply interested in its welfare throughout the rest of his life. He served a term as president of its Alumni Association and was a member of the Corporation of the Institute at the time of his death. In early life he was for two years professor of mathematics and engineering at the Massachusetts Agricultural College and considered this experience a valuable part of his training for subsequent professional work. His scholarship went much farther than technical studies, however, and he was well informed in many branches of literature and art. He was a lover of Nature and his favorite recreation was climbing the mountains of California and Colorado. His summer home was in the Colorado Rockies, acquired recently, which he did not live to enjoy so fully as he had anticipated when he bought it.

It is difficult to dissociate his personal work from that of his associates in the firm of Metcalf & Eddy. He was not only an indefatigable worker himself, but also possessed the ability to draw out the best work of which others were capable. A good deal that he accomplished was supplemented by them, so that his firm was marked by the team work it did and it is best, therefore, to leave an outline of his engineering accomplishments to the memoir of his career which will be issued later by the American Society of Civil Engineers.

His contributions to our own Association were so many, his cheerful personality was welcomed by so many of our members, his wise counsel so highly valued, that no other tribute is appropriate here than that in his passing from our midst we have lost one of the most sagacious, respected and beloved builders of our Association, as it is today.

John M. Goodell.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Distillery Waste Liquids and Their Purification. R. D. Littlefield. Chem. and Ind., **44**: 680. Seven page article describes in some detail character of waste liquors from distilleries and experimental plant for treating them. Wastes have exceedingly high oxygen demand, requiring in some cases 50,000 parts per million of dissolved oxygen for complete oxidation. For treatment, liquors were diluted with 10 volumes of water, precipitated with lime, and settled. Settled liquor was treated on trickling filter at rate of 20 gallons per cubic yard per 24 hours. Effluent from this process had five day biological oxygen demand of 4.3 parts per million, and was shown to be satisfactory for fish life by experiments in small hatchery.—*A. M. Buswell.*

Iodine and Water Supplies. H. W. Clark. Eng. News Rec., **95**: 470, 1925. Average I content of 80 Massachusetts water supplies examined was 2.14 parts per billion, individual supplies having content as high as 6.3 parts per billion. These results are being studied in relation to prevalence of goiter. Use of iodized salt is considered ideal method of overcoming I deficiency, application of I to water being considered more or less wasteful.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

System of sanitary grading of water supplies. E. Sherman Chase. Eng. News-Rec., **95**: 469–70, 1925. Consists of scale of values from 0 to 100 divided into 3 parts of 50, 20, and 30, which are assigned to factors for pollution hazards, protective measures, and quality condition, respectively. Maximum value indicates perfect or nearly perfect conditions.—*R. E. Thompson.* (Courtesy *Chem. Abst.*)

Phenol Tastes in the Water Supply of Marquette, Mich. Paul Hansen. Eng. News Rec., **95**: 469, 1925. Presence of pyroligneous acid and crude wood alcohol still wastes in the water supply of Marquette, derived from Marquette Bay, Lake Superior, has given rise to tastes and odors which are intensified by chlorination. On basis of Milwaukee experiments it is proposed that troublesome wastes be partially treated at works of origin and then discharged with city sewage into reaction tank (designed for possible conversion into activated sludge plant) with retention period of approximately 8 hours. Ratio of waste to sewage is approximately 1:15.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Close Water Control Important in Alumina Cement Concrete. P. H. Bates. Eng. News Rec., 95: 462–3, 1925. Experiments showed that marked decrease in strength accompanies use of excess water with high alumina cement, as little as 0.5 per cent (of weight of dry mix) causing distinct reduction. Grading of aggregate, by influencing amount of water required to secure workability, is also a factor.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Method for Testing Fine Aggregate. G. W. Hutchinson. Eng. News Rec., 95: 395, 1925. As standard test methods are of questionable economic value, attempt was made to devise method more consistent with use of fine aggregate under field conditions. Test adopted consists in proportioning materials as follows—dry volume: cement 23 per cent, fine aggregate 46 per cent, coarse aggregate 76 per cent employing a standard consistency analagous to that required in field concrete. Specimens, 3 x 6 inches cylinders, were stored in moist closet until compared with similar specimens made with standard Ottawa sand. Prepared coarse aggregate (Mascot Chats), grade $\frac{3}{8}$ to $\frac{3}{4}$ inch, was employed.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Chlorinator has Daily Capacity of 750 Pounds. Eng. News Rec., 95: 365, 1925. Injector type chlorinator, with capacity of 750 pounds per 24 hours, developed by Paradon Engineering Company for New York City water department for use with 1-ton containers used by that department, is described briefly and illustrated. Apparatus has range of capacity of $7\frac{1}{2}$ to 1 and is equipped with automatic chlorine shut-off device operated by water pressure.—*R. E. Thompson.* (*Courtesy Chem. Abst.*).

Use of Iodides in Water Supplies to Prevent Simple Goiter. Arthur F. Mellen. Eng. News Rec., 95: 352–4, 1925. Adverse criticisms of iodization are reviewed and commented on. Minneapolis supply, filtered Mississippi River water, contains only approximately 0.8 part per billion of I, compared with minimum content of 5 parts found in waters in non-goitrous regions. Author's proposal deficiency be corrected by addition of 10 parts per billion of NaI has been favorably considered. Cost is estimated at $1\frac{1}{2}$ cents per capita per annum.—*R. E. Thompson,* (*Courtesy chem. Abst.*)

Brookline, Mass. Eng. News Rec., 95: 259–60, 1925. Water supply (5 m.g.d.) is obtained from driven wells and underground collecting galleries located on banks of Charles River. Purification works consist of 6 tricklers, a sedimentation basin, and 6 slow sand filters.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Frozen Concrete Due to Undesirable Material. Walter H. Wheeler. Eng. News Rec., 95: 232, 1925. Brief discussion of failure of Gem Lake Dam in which opinion is expressed that dense concrete, equal to 1:2:4 mix in richness, made with clean aggregates which have water absorption of less than 1 pound per cubic foot, will not be disintegrated by freezing and thawing.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Suggests One-day Strength Test for Concrete Aggregate. Searcy B. Slack and J. E. Boyd. Eng. News Rec., **94**: 1014–5, 1925. Results of experiments employing alumina cement and 1-day test period for strength and compression tests of concrete aggregates are given which indicate that the 24-hour test is feasible and gives results comparable with present 28-day test with Portland cement.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Accelerated Sand Tests with Alumina Cement. N. W. Dougherty. Eng. News Rec., **95**: 113, 1925. Parallel tests of sand for concrete using 7- and 28-day portland cement and 24-hour alumina cement methods gave comparable results except for compressive strength of limestone screening, which was low by latter method. Previous experiments have shown that limestone screening with portland cement gives unusually high tensile and compressive strength. (Cf. previous abstract.)—*R. E. Thompson.* (*Courtesy Chem Abst.*)

Pumping Station Improvements at York, Pa. F. G. Cunningham. Eng. News Rec., **95**: 135, 1925. Water supply is pumped from Cadorous Creek against static lift of 290 feet to large reservoirs on a hill, filtered, and distributed by gravity. New boiler, and additional pump and filter units have recently been contracted for.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Annapolis, Md. Eng. News Rec., **95**: 95, 1925. Water is drawn from impounding reservoir on Broad Creek and passed through sedimentation basin to reservoir from which it is delivered by gravity to mains. Purification by filtration is under consideration.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Variable Cement Tests. Wm. Mueser. Eng. News Rec., **95**: 154, 1925. Instance of discrepancies in results of examination of concrete materials carried out in different laboratories is cited and commented on It is suggested that there is widespread doubt as to reliability of cement testing.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

City of Washington Builds Nine-Mile Aqueduct. Eng. News Rec., **95**: 88–93, 1925. Illustrated description of what is virtually a second water supply system for Washington, D. C., comprising aqueduct, rapid sand gravity filter plant of 80 million gallons per day capacity (20 units), 2 high pressure reservoirs, and a hydro-electric plant for generating power for pumping. Estimated expenditure involved is $9,000,000. Plant for alum manufacture has been included.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Well-managed Private Water Plant at Lexington, Ky. Eng. News Rec., **95**: 62–3, 1925. Works of Lexington Water Company consist of 2 series of impounding reservoirs, rapid sand filter plant, and necessary pumping equipment. Services are 100 per cent metered and average daily per capita consumption is 85 gallons. Meters are read at rate of 70 per man-hour. Coal consumption in boiler plant has been reduced from 32,000 to 20,000 pounds per 24 hours in last 3 years, notwithstanding 5 per cent increase in water use (4 to 4.2 million gallons per day).—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Greensboro, N. C. Eng. News Rec., 95: 61, 1925. Water is pumped from billion-gallon impounding reservoir on Reedy Fork Creek to 20 million-gallon reservoir from which it flows 6 miles by gravity through two 24-inch mains (one cast iron, the other wood) to filtration plant which was constructed 2 years ago.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Wilmington, N. C. Eng. News Rec., 94: 1018, 1925. Purification of the water supply, which is drawn from Cape Fear River, has presented difficulties owing to variable color and turbidity. Notwithstanding purity of water as at present delivered, city is still compelled to maintain 37 deep wells to which people come for drinking water. Average quality of city water is as follows:—alkalinity 14.4; chlorides 5; turbidity 0; odor, none; total bacterial count at 38°, 2; B. coli absent in 50 cc.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Ventilation Methods in Florence Lake Tunnel. Eng. News Rec., 94: 1010–12, June 18, 1925. Ventilation methods employed during construction of Florence Lake tunnel of Southern California Edison Co., described. Factors found to be important were: use of auxiliary blowers as boosters when lines exceeded 10,000 feet in length, use of curtain of small jets of compressed air to retain powder gases near heading until foul air could be exhausted, and improvement in size of cartridge and materials used in blasting. Three types of ventilating pipe, wood-stave, corrugated iron lined with sheet metal, and plain 12-gage steel, were employed; all 24 inches in diameter. Latter was found most satisfactory, as drying of staves of wood pipe resulted in leakage, and friction losses in corrugated pipe were excessive.—*R. E. Thompson.*

Centrifugal Pumps at Waterville Meet Unusual Requirements. Arthur L. Shaw. Eng. News Rec., 94: 1020, June 18, 1925. Due to varying friction losses in 8.4 miles of supply aqueduct at different pumping rates, head on suction side of pumps ranges from 90 feet static pressure to 12 feet suction lift, and difficulty has been experienced in obtaining reasonable pumping efficiency. Problem finally solved by pumping units consisting of series-connected single-stage pumps which can be operated singly when desired. Characteristics of units shown graphically.—*R. E. Thompson.*

Automatic Spillway Gates of Black Canyon Dam. Julian Hinds. Eng. News Rec., 94: 1046–50, June 25, 1925. Conditions under which diversion dam across Payette River will be operated are such that flood water must be passed with practically no increase in water level, and to meet these requirements crest gates of drum type, operated by variation in water level, have been in-installed. The gates, automatic control device, and special rubber seal employed are described in some detail and illustrated.—*R. E. Thompson.*

Present Status of San Francisco's Hetch Hetchy Project. Eng. News Rec., 94: 1021–3, June 18, 1925. Work completed, under construction, and proposed, outlined. To date approximately $44,000,000 has been expended on project; a $10,000,000 bond issue was approved last October, and further issue of $23,000,000 will be required to complete work. Present consumption in San

Francisco is approximately 42 m.g.d. and maximum amount which can be brought in economically from all sources prior to Hetch Hetchy delivery is 60 m.g.d., which will meet requirements for no longer than next 6 years. Estimated that project can be completed in that time.—*R. E. Thompson.*

Design Considerations of Dix River Rock-Fill Dam. Eng. News Rec., 94: 1058–61, June 25, 1925. Upstream face of dam was built to slope of 1 on 1.2 at bottom changing to 1 on 1 at top, and is protected by tightly laid dry rubble slope-wall placed directly on rock fill, 14 feet in thickness at base and 7 feet at normal water level, and by concrete pavement ranging in thickness from 18 inches at bottom to 8 inches at top. The concrete forms for lower 160 feet, constructed of well-seasoned, tongued and grooved, 3 x 10 yellow pine lumber, bolted into the concrete, will be left in place permanently as additional safeguard against seepage. It is believed that sheeting will swell to form very tight diaphragm, as permanent under water as concrete itself, or possibly more so.—*R. E. Thompson.*

Corroborates Some Doubts Raised by Milwaukee Experiments. J. W. Ellms. Eng. News Rec., 94: 1062, June 25, 1925. E. believes that use of wood-grating filter underdrains, such as those at Sacramento (cf. this Journal, 14: 4, 364) would result in uneven washing unless velocity in main channel and separate waterways was very low. Use of cemented-gravel layer is not favored, as velocity head can be controlled more easily in strainer system than in gravel layer. Gravel depth of 18–21 inches considered most satisfactory. (See following abstracts.)—*R. E. Thompson.*

Metal Distribution More Dependable Than Gravel. Wellington Donaldson. Eng. News. Rec., 94: 1062–3, June 25, 1925. D. considers "metal" distribution of wash water to be more dependable than "gravel" distribution, owing to low resistance of latter. An objection to cemented-gravel layer is possibility of clogging and inability to overhaul without complete destruction and replacement. Air entrainment should be combated at source rather than by modification of underdrains. (See previous and following abstracts.)—*R. E. Thompson.*

Baltimore Experience with Slat Bottom Type Satisfactory. Jas. W. Armstrong. Eng. News Rec., 94: 1063–4, June 25, 1925. Sacramento results can be explained by thin layer of gravel employed. With proper depth and grading of gravel, cemented-gravel layer, as suggested, would be unnecessary. One filter of slat bottom type has been successfully operated in Baltimore for 4 years and additional units are under construction. (See previous and following abstracts.)—*R. E. Thompson.*

Iron Ridge Block Diffusers and Wood Grating Used at St. Paul. John W. Kelsey. Eng. News Rec., 94: 1064, June 25, 1925. Filters equipped with iron ridge block diffusers and wood grating have proved satisfactory at St. Paul, giving uniform wash at rate of 2 feet vertical rise per minute. (See previous and following abstracts.)—*R. E. Thompson.*

Cemented-Gravel Slabs Satisfactory at Toronto and Elsewhere. Wm. Gore. Eng. News Rec., 94: 1064–5, June 25, 1925. Cemented-gravel layer, resting upon loose gravel covering perforated pipe underdrains and covered with 2 inches of coarse sand, has been successfully employed in drifting sand filters to prevent interference of gravel with operation of sand extractors. Recent examination at Toronto showed that cement was being slowly dissolved by water and that layer, although sound, was more porous than when placed 6 years before. Proportion of cement has been increased from 1:15 to 1:12. (See previous abstracts.).—*R. E. Thompson.*

Flow Losses in Large Pipes (and Open Channels). Harrison P. Eddy. Eng. News Rec., 94: 1070, June 25, 1925. Excess loss, of head in curves and bends is probably due largely, if not wholly, to disturbance of flow conditions by which thread of maximum velocity is deflected nearer outside of curve and velocity filaments in contact with wetted perimeter in this portion correspondingly increased as compared with those obtaining when flow is in straight lines. This probably results in considerable increase of average velocity of filaments in contact with surface of conduit and consequently in increased frictional loss, while mean velocity remains unchanged. (Discussion of article of F. C. Scobey, cf. this Journal, 14: 6, 602).—*R. E. Thompson.*

Drains Under Earth Dams. Allen T. Blythe. Eng. News Rec., 94: 1070, June 25, 1925. Discussion of failure of French Landing Dam (cf. this Journal, 14: 5, 480) and of advisability of employing drains.—*R. E. Thompson.*

Drains Under Earth Dams. Gardner S. Williams. Eng. News Rec., 94: 1070–1, June 25, 1925. Reply to above, quoting successful applications.—*R. E. Thompson.*

Probability Methods for Rainfall and Run-off. Chas. W. Sherman. Eng. News Rec., 94: 1071, June 25, 1925. Discussion of article of S. L. Moyer (cf. this Journal, 14: 6, 603) with reference to advisability of using yearly maximum as essential data, and omitting all secondary maxima even though materially higher than some of yearly maxima. (See following abstract.)—*R. E. Thompson.*

Probability Methods for Rainfall and Run-off. S. L. Moyer. Eng. News Rec., 95: 74, July 9, 1925. Reply to above.—*R. E. Thompson.*

Coefferdam Built to Dislodge Cleaning Ball in Lake Outlet Sewer. Chas. A. French. Eng. News Rec., 95: 10–1, July 2, 1925. Cleaning ball which had become lodged 50 feet from shore in lake outlet at Laconia, N. H., was removed by constructing cofferdam and cutting opening in pipe with electric drill. Opening was repaired by clamping plate to pipe, calking with sheet lead, and embedding in concrete.—*R. E. Thompson.*

Multiple Arch Dam Disintegrated Under Low Temperatures. Eng. News Rec., 95: 22–3, July 2, 1925. Disintegration of concrete of multiple arch dam

on Gem Lake, California, attributed to frost, described and illustrated. Structure was repaired by pouring concrete gravity section behind arches.—*R. E. Thompson.*

Subaqueous Pile Driving at Portland, Ore. Eng. News Rec., **95**: 53–4, July 9, 1925. Pile driving to depth of 65 feet below water surface by means of subaqueous hammer described and illustrated.—*R. E. Thompson.*

Partial Failure of Earth Dam at Horton, Kans. E. B. Black. Eng. News Rec., **95**: 58–9, July 9, 1925. Illustrated description of partial failure of dam forming Mission Lake, from which Horton, Kans., derives its water supply. Data on record-breaking rainfall and flood which overtopped dam, and brief details of temporary and permanent repairs carried out, included.—*R. E. Thompson.*

Testing an Arch Dam. Fred A. Noetzle. Eng. News Rec., **95**: 74, July 9, 1925. Brief reference to experimental program in connection with proposed test dam of Engineering Foundation (cf. this Journal, **14**: 5, 480).—*R. E. Thompson.*

Hydraulic Turbine of New Design Developed in England. F. Johnstone-Taylor. Eng. News Rec., **95**: 72–3, July 9, 1925. Banki turbine, for development of small quantities of power at low-head, described and illustrated. Wheel will operate with loss of efficiency of not more than 10 per cent when completely submerged.—*R. E. Thompson.*

New Graphic Water Level Recorder Has Range of Use. Eng. News Rec., **95**: 80, July 9, 1925. Brief description of instrument manufactured by W. and L. E. Gurley, Troy, N. Y.—*R. E. Thompson.*

New Formula for Flow of Water in Clean Cast Iron Pipe. Edward Wegmann and Albert N. Aeryns. Eng. News Rec., **95**: 100–2, July 16, 1925. Formula given which agrees more closely with experiments than any other. Average per cent variation in velocity from that by new formula is as follows: experiments (260 records were found, some of which showed marked variations), −0.5; Hazen and Williams, +5.6; Williams, +1.1; Ganguillet and Kutter, +1.1; Barnes, −5.6; Lampe, +4.2; Flamant, +5.9.—*R. E. Thompson.*

Sanitary Protection of Water Supplies Taken from National Forest Areas. Eng. News Rec., **95**: 113–4, July 16, 1925. Discussion of sanitation of National Forest Areas by J. B. Marcellus, Lee H. Williamson, Richard Messer, and L. F. Knopp, with particular reference to Reserve in which watershed from which Staunton, Va., derives its supply is situated. Details of co-operative watershed agreement between Staunton and Dept. of Agriculture given by latter writer.—*R. E. Thompson.*

Aurora, Ill. Eng. News Rec., **95**: 133, July 23, 1925. Water supply, obtained from wells in Potsdam sandstone, although hard, is cool and free from contamination and is considered excellent supply.—*R. E. Thompson.*

Lining Pit No. 3 Tunnel Using Pneumatic Concrete Guns. Eng. News Rec., 95: 128–32, July 23, 1925. Illustrated description of process of lining tunnel 4 miles in length and 19 feet in diameter.—*R. E. Thompson.*

Yellow Paint Used for Fire Hydrants. Eng. News Rec., 95: 135, July 23, 1925. Yellow metallic paint has been substituted for red on hydrants in New London, Conn., and found very effective, being more resistant than red to salty and frequently foggy air of that section of country.—*R. E. Thompson.*

What Happened to Municipal Utilities at Santa Barbara. Eng. News Rec., 95: 146–9, July 23, 1925. Damage to water supply system during earthquake of June 29 included breaks in mains and failure of centre section of dam in Sheffield reservoir in city. Condition of latter suggests that structure was previously weakened by seepage under cutoff wall. Gibraltar Dam, storing city's water supply on Santa Ynez River, was undamaged. Increased flow observed since quake is attributed to release of imprisoned pockets of water. Sewer outfall, including submerged section, was disaligned and some joints broken, and it is believed that considerable portions will require relaying.—*R. E. Thompson.*

Grand River Crossing—Spavinaw Water Supply Conduit. W. R. Holway. Eng. News Rec., 95: 168–71, July 30, 1925. Chief construction difficulties involved in laying of 54-inch and 60-inch concrete pipe for 55-mile gravity conduit of Spavinaw Water Project of Tulsa, Okla., were due to fact that line had to be located across lines of natural drainage, necessitating crossing of 17 large streams. Excavation of pipe trench in river beds was accomplished with cofferdams constructed alternately of cribs and gates. Crossing of Grand River, which was largest and most difficult undertaking, described and illustrated. River at point of crossing is 800 feet wide and this section of 60-inch pipeline took from April to October to complete and cost approximately $125,000.—*R. E. Thompson.*

Flood Protection Studies for Syracuse. Eng. News Rec., 95: 153, July 23, 1925. Flood possibilities and feasible methods of protection from floods at Syracuse, N. Y., are to be studied by Syracuse Intercepting Sewer Board. Flood of 3500 second-feet on Onondago Creek at Syracuse in 1901 was greatest recorded to that date, but it was exceeded in 1914 (3600 second-feet), 1915 (5500), 1920 (6000), and 1925 (5500). Possibilities of channel enlargement within city are restricted and detention works upstream may have to be considered.—*R. E. Thompson.*

Features of Newark, Ohio, Water Softening Plant. Clarence T. Kaiser. Eng. News Rec., 95: 174–5, July 30, 1925. Newark water treatment plant consists of 2 settling basins, 4 mechanical filters, clear water reservoir, 2 dry-feed machines for alum, 2 feeders for milk of lime, and chlorinator. Features of softening plant are replaceable concrete slabs at water line on baffle boards of settling basins to facilitate repair of damage of concrete due to frost, and Dorr clarifier for continuous removal of sludge. Split treatment is employed

as water is high in magnesium. Water is finally carbonated with gas derived from breeching of boilers, which is scrubbed and dried and applied through diffusers consisting of perforated pipe surrounded by cemented sand (1:12 mixture).—*R. E. Thompson.*

Quantity Production of Ground Water from Wells in Sand. J. G. Gordon. Eng., News Rec., 95: 188–9, July 30, 1925. Velocity of ground water increases rapidly as it approaches well, and use of gravel wall, by increasing distance between sand and well, reduces velocity of water leaving sand and, therefore, amount of sand carried into well. Gravel wall also reduces friction loss, thus increasing specific capacity.—*R. E. Thompson.*

Measuring the Physical Effect of Corrosion. E. Blough. Eng. News Rec., 95: 185, July 30, 1925. Common criticism applicable to all current methods of determining extent of corrosion is that effect of corrosion on residual metal which is apparently unattacked is not disclosed. Suggested that specimens after corrosion should be subjected to physical tests. Application demonstrated.—*R. E. Thompson.*

Rigidity of Penstock Wye Secured by Simple Design. Eng. News Rec., 95: 189, July 30, 1925. Near upper end of penstock supplying water to Moccasin Creek power house on Hetch Hetchy Project, two 98-inch riveted steel pipe lines branch, by means of two Y's into four lines, each 66 inches in diameter. Design of this section briefly described and illustrated.—*R. E. Thompson.*

Sheffield and Gem Lake Dam Failures. M. M. O'Shaughnessy. Eng. News Rec., 95: 194; July 30, 1925. Failure of Sheffield and Gem Lake (see above) dams discussed. Suggested that former was due to defective materials used in construction rather than to frost. Installation of drains on downstream portion of earth-fill dams favored.—*R. E. Thompson.*

From Filters to Small Wells Then to Large Wells. W. A. Cone. Eng. News Rec., 95: 216–7, August 6, 1925. Filtered Alabama River water supply was abandoned some years ago by Montgomery, Ala., in favor of small wells and air-lift pumping equipment. Decreasing production of system and greatly increased power rates resulted in recent installation of 5 Layne and Bowler wells equipped with vertical centrifugal pumps which has reduced cost of pumping from wells to reservoirs from 2.58 cents to 0.9 per 1000 gallons. Estimated that saving will equal cost of new equipment in 3 years. Efficiency of air-lift system (electrical input to water output) was only 10.6 per cent.—*R. E. Thompson.*

Automatic Valve Control Device Eliminates Water Hammer. Eng. News Rec., 95: 200, July 30, 1925. Brief description of device, manufactured by Chicago Valve and Hydrant Company, that will automatically open gate, butterfly, and check valves when required pressure has been built up, or close same when power is shut off. Additional use is for automatically opening and closing valves at any predetermined rate of flow where break in mains would ordinarily drain supply.—*R. E. Thompson.*

Indianapolis Flood Protection is Progressing. Eng. News Rec., 95: 213, August 6, 1925. Flood protection work on White River in Indianapolis, two sections of which were completed in 1915–1918 as direct result of flood of March-April, 1913, is being continued. Improvement includes widening and rectification of river and lower part of its tributary, Fall Creek, and construction of levees along bank of new channel. Brief details of work under construction and proposed given.—*R. E. Thompson.*

Open Sea Construction of a Concrete Pipe Sewer Outfall. H. A. Norman. Eng. News Rec., 95: 292–4, August 20, 1925. Construction of ocean outfall from Hyperion treatment plants, Los Angeles, described and illustrated. Main trunk outfall is 5443 feet long and 7 feet in diameter, and depth of water at outshore end is 60 feet. Surf, ground swell, and heavy north and south coastwise currents were normal water conditions, much aggravated by storms. These hazards were met without serious mishap by method of submerged towing—lengths of pipe being hung from bottom of special pontoon which was towed to desired position and submerged, being again floated after placing of pipe section. Cofferdam was employed for first 800 feet—through surf. Contract price was $496,000.—*R. E. Thompson.*

Belt Conveyors Build Wanaque Dam Embankment Core Wall. Eng. News Rec., 95: 252–8, August 13, 1925. Project consists of main earth dam with concrete core wall on Wanaque River, five subsidiary dams—two of concrete and three of earth with core walls—aqueduct, and tunnel, object being to supplement present Pequannock River supply of Newark, N. J., and to serve Paterson and other neighboring municipalities which may contract for water. Reservoir will be 6 miles long and one mile wide and is situated 25 miles north of Newark. Capacity will be approximately 28,000,000,000 gallons, giving supply of 100 m.g.d. Main dam contains 830,000 cubic yards of embankment, and other three earth fills aggregate approximately 120,000 cubic yards. Concrete amounts to 77,000 cubic yards—30,000 in main dam. Excavation in rock is equivalent to 40,000 cubic yards, and earth excavation over 113,000. Probably greatest footage of belt conveyers (nearly 2½ miles) ever operated on construction job, have been installed. Excavation, fill, and haulage are also all-mechanical operations. Animals are not allowed to work within reservoir site. Construction of dams described and illustrated in some detail.—*R. E. Thompson.*

Setting Up Depreciation Reserves. Wm. E. Oberle. Eng. News Rec., 95: 278–9, August 13, 1925. Discussion of methods of creating depreciation reserves. Suggestion is made that subject be thoroughly analyzed in order that future methods may be based on sound practice.—*R. E. Thompson.*

Water Tank Collapses Injuring Two. Eng. News Rec., 95: 319 and 321, August 20, 1925. Collapse, in New York City, of 20,000-gallon wood-stave water tank supported on steel tower, described briefly. Tower was 60 feet in height and was erected 25 years ago. Corrosion stated to be contributing factor.—*R. E. Thompson.*

New London, Conn. Eng. News Rec., **95**: 305–6, August 20, 1925. Water supply is derived from Lake Konomoc, a 600-m.g., storage supply 6 miles from city, with auxiliary reservoirs of 212 and 160 m.g., 9 and 11 miles from city. Chlorination is only treatment employed. Distribution is by gravity, pressure being equalized by pumping to small reservoir within city.—*R. E. Thompson.*

Why Not Two Water Mains in Wide Streets? Thomas F. Wolfe. Eng. News Rec., **95**: 332–5, August 27, 1925. Two-main system, one main large enough for domestic consumption on one side of street and fire protection on both sides, and other smaller and having no fire hydrant connections, advocated. Advantages are elimination of difficulties regarding services to vacant lots on streets about to be paved, and reduction in cost of locating and repairing leaks. With streets 80 feet wide from lot front to lot front, blocks 660 feet long, pavement 33 feet wide, lots 25 feet wide and 1-inch lead service pipes, cost of main and service installations under each plan (8-inch pipe alone, or 4-inch and 8-inch on either side) are practically identical. Comments of 27 water works engineers and superintendents included. Additional remarks by 5 writers in Eng. News Rec., **95**: 522–3, September 24, 1925.—*R. E. Thompson.*

New Tower for Water Tank Houses Pumps at Rochester, Minn. Eng. News Rec., **95**: 338–9, August 27, 1925. Brief illustrated description of covered, reinforced-concrete, 200,000-gallon water tank constructed in 1924 to supplement 240,000-gallon wrought iron standpipe installed as part of original works in 1887. Other improvements include tubular wells and additional pumping units, part of latter being housed in tower supporting tank.—*R. E. Thompson.*

New Gravity Water Supply for Whitehall, N. Y. Jas. P. Wells. Eng. News Rec., **95**: 344–5, August 27, 1925. New 3 m.g.d. supply of soft and bacteriologically satisfactory water from Pike Brook and Pine Lake, replacing supply from Metawee River which was moderately hard and at times unsatisfactory in quality, described briefly. Features of system are considerable length of pipe laid almost unprotected on rock with an exposure to very low temperatures, and submerged section laid on soft bottom of arm of Lake Champlain. Exposed section has already had severe test, having been subjected to temperature of −45° at low velocity without appreciable decrease in discharge.—*R. E. Thompson.*

Electrically-Operated Gages Devised For Filters. Harry N. Jenks. Eng. News Rec., **95**: 346–8, August 27, 1925. Loss-of-head gages and valve-opening indicators consisting of voltmeters actuated by current varied through reactance coils, developed at Sacremento filtration plant, described and illustrated. Deflection in former is sufficient to enable readings of 0.1 foot. Cost believed to be much less than for any other type—$45 for loss-of-head gage and $10 for valve-opening indicator. Principle involved may be applied to great variety of uses—indications may be had of pressure, difference in pressure, and physical motion at any desired remote point. Invention is not covered by patents and free use is permitted.—*R. E. Thompson.*

Effect of Rio Grande Storage on River Erosion and Deposition. L. M. LAWSON. Eng. News Rec., 95: 372–4, September 3, 1925. Control of flow of Rio Grande by Elephant Butte dam, forming reservoir of 2,600,000 acre-feet capacity, has prevented large destructive floods and greatly reduced total sediment in lower river. Average annual flow at San Marcial since 1897 has been 1,225,727 acre-feet (1550 second-feet continuous flow) with maximum measured flood discharge of 33,000 second-feet. Silt content is approximately 20,000 acre-feet per annum.—*R. E. Thompson.*

Channel Improvement of Rio Grande Below El Paso. SALVADOR ARROYO. Eng. News Rec., 95: 374–6, Sept. 3, 1925. Control works on Rio Grande have resulted in deposition of sand in channel below El Paso, making it inadequate, causing river to become menace to cities and irrigation development along both banks. Brief details of plan of river rectification which has been submitted to American and Mexican Governments by author and L. M. LAWSON given.—*R. E. Thompson.*

Irrigation Tunnel Constructed in Earth and Hard Clay. J. K. ROHRER. Eng. News Rec., 95: 393–4. Construction of 6500-foot irrigation tunnel near Mitchell, Neb., for U. S. Bureau of Reclamation described briefly. Tunnel is of horseshoe section, 10 feet 3 inches high, with 10-inch concrete lining. Approximately 1390 feet at north end and 1100 feet at south end are in earth, and remainder in hard clay. Timbering was required throughout.—*R. E. Thompson.*

Multiple-Arch Dams Exposed to Frost. SPENCER W. STEWART. Eng. News Rec., 95: 396, September 3, 1925. Discussion of failure of Gem Lake dam (see above), which is believed to have been primarily due to porosity caused by use of treacherous concrete materials.—*R. E. Thompson.*

Use of Burned Clay, Concrete and Wood Pipe for Irrigation. R. K. TIFFANY. Eng. News Rec., 95: 419, September 10, 1925. Brief illustrated description of construction of irrigation system of Spokane Valley Irrigation District, feature of which was use of bell-less vitrified clay pipe which was very satisfactory. This type of pipe can be manufactured for 15 per cent less and laid for 10–20 per cent less than bell-and-spigot type.—*R. E. Thompson.*

Wisconsin Supreme Court Enjoins Stream Pollution. WM. R. COPELAND. Eng. News Rec., 95: 390–1, September 3, 1925. Review and discussion of award of $50,000 damages to riparian owner by Supreme Court of Wisconsin for flooding of farm land and creation of public nuisance in waters of Honey Creek by raw and partially treated sewage discharged into stream by city of West Allis. The city was ordered to abate the nuisance within 60 days. The sewage treatment plant, consisting of contact beds and Imhoff tanks, removes 55–60 per cent of organic impurities.—*R. E. Thompson.*

Middletown, Ohio. Eng. News Rec., 95: 425–6, September 10, 1925. Water supply is obtained from 11 6-inch wells. Consumption is 5 m.g.d. and it is

estimated that at least 10 m.g.d. is used by industries from private wells. Upon completion of 100 per cent metering a number of years ago pumpage decreased 25 per cent. Large number of household softening plants are in use in city.—*R. E. Thompson.*

Publicizing Plans for Municipal Works. S. Harold Evans. Eng. News Rec., 95: 426–7, September 10, 1925. Graphical representation of conditions in connection with $500,000 water project of Eugene, Ore., played important part in allaying adverse criticism and in gaining strong support for the undertaking, which consists of substituting potable supply from 7 miles up McKenzie River for present supply from Willamette River, which is dangerously polluted.—*R. E. Thompson.*

Effect of Berms on Flow in Alamo Canal. G. G. Sypes. Eng. News Rec., 95: 433, September 10, 1925. Discussion of measurement and control of flow in Alamo Canal. Breakdown in flow relation at critical stage is attributed to berms formed around roots of trees and brush on banks.—*R. E. Thompson.*

A Plan for a Metropolitan Water District in New Jersey. Eng. News Rec., 95: 436, September 10, 1925. Financial and administrative plan drawn up by Clemens Herschel and submitted to commission created by New Jersey Legislature to formulate comprehensive water supply policy for state is outlined briefly.—*R. E. Thompson.*

More Data on Tulsa Pipe Line Venturi Meter. Fred C. Scobey. Eng News Rec., 95: 442, September 10, 1925. Additional data, particularly as regards loss-of-head (cf. this Journal, 14: 6, 602).—*R. E. Thompson.*

Water Meter Ordinance for City of Chicago. Eng. News Rec., 95: 443, September 10, 1925. Ordinance has been passed providing for universal metering of water service in Chicago in 10 annual installments. In addition, present meter rate of $62\frac{1}{2}$ cents per 1000 cubic feet, subject to 25 per cent discount has been changed to 60 cents, subject to 15 per cent discount, making net increase from 46.9 to 51 cents. This is not sufficient to enable carrying out of filtration program, which would require 40 per cent increase.—*R. E. Thompson.*

Driving Wanaque Tunnel for North Jersey Water Supply. Eng. News Rec., 95: 460–1, September 17, 1925. Illustrated description of construction of 860-foot tunnel to carry supply line under overflow channel of dam.—*R. E. Thompson.*

Water Main Breaks at Congested Corner of Fifth Avenue, New York City. Eng. News Rec., 95: 463, September 17, 1925. Break in 20-inch cast iron bell-and-spigot pipe and repair of same described briefly. Such breaks seem to occur as result of traffic load which pipes are required to carry in excess of that for which supports were designed.—*R. E. Thompson.*

Additional Drainage Works in Little River District. E. S. Blaine. Eng. News Rec., 95: 496–500, September 24, 1925. Extensive additional works being carried out to provide adequate drainage and flood control under conditions which have developed since original works were constructed some 10 years ago included multiple main ditches, retarding basins, and high-level flow-line ditches, latter being employed in preference to floodways for high-water flow. Works described in some detail and illustrated, and relative merits of high flow line ditches and floodways compared.—*R. E. Thompson.*

Test Program For Arch Dam Investigation. Eng. News Rec., 95: 510, September 24, 1925. Brief data on test program.—*R. E. Thompson.*

Santa Monica, Calif. Eng. News Rec., 95: 511–3, September 24, 1924. Three new wells have been drilled and new pumping equipment installed. Supply is of excellent chemical quality, although slightly hard. Average consumption is 4 m.g.d. One million dollars has recently been expended on extensions to distribution system, which is wholly constructed of cast iron.—*R. E. Thompson.*

Measuring Sewage Flow By Pitometer. Arthur L. Shaw. Eng. News Rec., 95: 518, September 24, 1925. Device described by means of which pitometer orifices may be flushed to remove adhering solids.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

How to Plan District Water Supplies. Arthur H. Pratt. Eng. News Rec., 95: 560, October 1, 1924. Discussion of water supply situation in New Jersey with particular reference to North Jersey District Water Supply Commission, being reply to recent editorial on this subject.—*R. E. Thompson.*

Roofed Reservoir and Pipe Tunnel for Small Water System. Eng. News Rec., 95: 540–2, October 1, 1925. Calumet City (formerly West Hammond) recently contracted with Chicago for supply of 2 m.g.d. at 62½ cents per 1000 cubic feet, and has constructed 2 m.g. circular concrete reservoir with tunnel to carry inlet main under Grand Calumet River. There are now 33 suburban or outlying towns supplied by Chicago, aggregate consumption being 17½ m.g.d.—*R. E. Thompson.*

Computing Backwater Curves for Surface Slopes in Streams. J. C. Stevens. Eng. News Rec., 95: 550–2, October 1, 1925. Method suitable for irregular channels described.—*R. E. Thompson.*

Financing Main Pipe Extensions by Assessment Method. Caleb Mills Saville. Eng. News Rec., 95: 471, September 17, 1925. Brief data on financing main extensions in Hartford, where assessment method has been used for several years, given. A 75-foot exemption is allowed on corner lots, and street intersection costs are paid for by city.—*R. E. Thompson.*

Municipal Watershed Reforestation in New York State. Eng. News Rec., 95: 475, September 17, 1925. Forty cities in New York State are participating in reforestation movement and have in excess of 10,000 acres of young forests, most of which are planted on watersheds. Rochester has been active in forestation since 1909 and its watershed contains 1,086,000 trees. Glen Falls began planting in 1910 and intends to cover entire watershed. Hills around Saratoga Springs contain 1,290,000 trees. Troy has planted half million and Little Falls almost as many.—*R. E. Thompson.*

Some Features of Filter Design. JAS. W. ARMSTRONG. Eng. News Rec., 95: 470–1, September 17, 1925. Since construction of Loch Raven Reservoir (Baltimore) maximum 20 degree count has been reduced from 800,000 to 13,000 per cubic centimeter and maximum turbidity from 5,000 to 200 p.p.m. Maximum temperature has been reduced 6°F. To obtain maximum efficiency with coagulation, water should be violently agitated immediately after addition of coagulant. Later agitation is ineffective. Experiments carried out at Baltimore with mixing basins of around-the-end type with 13 180° turns showed a distinct gain in subsiding value of the water at each successive turn. Reinforced concrete in contact with water has been found to have tendency to disintegrate, particularly in cold climates, two important factors being quality of sand and imperviousness of concrete. Seepage of water through concrete, particularly where subject to frost action, will lead to ultimate disintegration. Water of pH value less than 7.5 and alkalinity less than 100 dissolves calcium carbonate from concrete, and aluminum compounds also slowly go into solution, resulting in loss in strength, rapidity of destruction depending largely on porosity.—*R. E. Thompson.*

Eugene, Ore. Eng. News Rec., 95: 472–3, September 17, 1925. Water dept. is under control of water board and is operated, as much as possible, like private corporation. All city services are metered and billed in same manner as private consumers—there is no "free service." Supply is at present drawn from Willamette River, but supply from McKenzie River will shortly be substituted. Maximum demand is 3–4 m.g.d., and average per capita consumption, 110 gallons daily. Douglas fir in wood-stave pipes of distribution system is in excellent condition after 16 years' service, but spiral steel wire binding has deteriorated in some places close to electric railway lines, due probably to electrolysis, deterioration being confined to under side of pipe, where bands were completely destroyed although no rust or corrosion was evident on other parts of same wraps.—*R. E. Thompson.*

Drains Under Earth Dams. C. C. DALAL. Eng. News Rec., 95: 483, September 17, 1925. Discussion of employment of drains under earth dams and of line of saturation of undrained dams. Drains favored only where signs of sloughing are evident.—*R. E. Thompson.*

Bronze Welding Procedure for Cast Iron Pipe. Eng. News Rec., 95: 566, October 1, 1925. Bronze welded joints, because of their equally strong structure and lower forming-temperature, have advantages over cast iron welded

joints, especially under field conditions. Of 22 bronze welded pipe lines laid in 1924 in widely separated parts of North American Continent, 12 showed no defects, 8 had minor defects only, and 2, serious defects, latter being attributed to acknowledged porosity and laminations at end of pipe which contributed to defective weld. Code of field rules derived from collected data included.—*R. E. Thompson.*

Penstock Air Valve. Eng. News Rec., **95**: 567, October 1, 1925. New air valve manufactured by Coffin Valve Co., Boston, Mass., described and illustrated.—*R. E. Thompson.*

Water and Water Supplies. H. S. Hancock, Jr. Pub. Health J. (Can.), **16**: 36–42, 1925. Early history of public water supplies is outlined, and supply of Fort William, Ont., derived from Loch Lomond, 6 miles from city, is described. —*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Ten Million Gallon per day Filtration Plant for the City of St. Catharines. Cont. Rec., **39**: 366–8, 1925. Owing to increasingly unsatisfactory bacteriological quality of present water supply, derived from Welland Canal, city of St. Catharines has contracted for installation of 10-m.g.d. filter plant, brief details of which are given. Works were designed as part of proposed zone scheme for number of municipalities deriving supply from same source, with estimated requirements of 16 m.g.d. in 10 years' time.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Peaty Stains in Water. Munic. Eng., **76**: 246, 1925. As result of complaints from textile firms and domestic consumers regarding color of water from Chellow Heights reservoir, Bradford, Eng., Corporation has contracted for installation of coagulation basins and 12-m.g.d. rapid sand filter plant, to be operated at rate of 93 gallons per square foot per hour. Effluent will be passed through existing slow sand filters. Installation is similar to 48-m.g.d. plant under construction for Metropolitan Water Bd., and 3-m.g.d. plant at Kilmarnock. Rate of filtration at latter works is 72 gallons per square foot per hour, and operation is controlled by observation of color of effluent, which is passed through inspecting boxes lined with white glazed tile.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

The Purification of Swimming Bath Water. Munic. Eng. **76**: 217, 1925. Purification of water of municipal pools of St. Helen's, of which there are 2, of aggregate capacity of 112,000 gallons, is effected by filtration through Paterson pressure filters after addition of coagulant, aëration with compressed air, and chlorination with Chloronome apparatus at rate of approximately 0.5 p.p.m. Water is circulated at rate equivalent to complete replacement every 10 hrs., and is heated to 72° F. in summer and 78°F. in winter. After 19 weeks continuous use, examination showed B. coli and B. enteritidis sporogenes to be entirely absent, total number of bacteria per cubic centimeter on gelatin, 3 days incubation, being only 112. There was no trace of free Cl_2 or of nitrites, and free and albuminoid ammonia and O_2 absorbed in 3 hrs. at 37° were 0.0046,

0.0058 and 0.045 parts per 100,000 respectively.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Some Observations on Endo's Medium. NORMAN MACL. HARRIS. Pub. Health J. (Can.), **16**: 326, 1925. Of 4 basic fuchsins examined with regard to suitability for use in Endo medium, one consisting of approximately equal proportions of rosanilin and para-rosanilin gave best results. Difco bacteriological peptone was found superior to 6 other brands tested for this medium. Substitution of 0.3 to 0.5 per cent K_2HPO_4 for meat extract in formula of Standard Methods (A. P. H. A.) is recommended.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Deep Well Supply for Cochrane, Ont. J. LANNING. Cont. Rec., **39**: 782–4, 1925. New supply of Cochrane, consisting of 2 Layne gravel wall wells and necessary pumping equipment, is described briefly and illustrated. Former supply, originating in springs, was abandoned as result of typhoid epidemic of 1922–3 (cf. this JOURNAL **10**: 725).—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

What is the Present Trend in Water Works Design and Operation? WELLINGTON DONALDSON. Cont. Rec., **39**: 854–7, 1925. Review and discussion of trend of water works practice with regard to aëration, sedimentation, coagulation, chemical application, filter sand bed, filter auxiliaries, and chlorination.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Public Swimming Pools in the City of Edmonton. Cont. Rec., **39**: 654–5, 1925. Three municipal pools in Edmonton, Alta., are described briefly. Water is circulated every 18 to 24 hours and is purified by filtration and chlorination with bleach, latter being controlled by o-tolidin test. Copper sulfate is used in small quantities to control algae growths.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Safeguarding Bathing Beaches. ANON. Public Health News (N. J.), **10**: 121–5, 1925. Majority of N. J. resorts discharge treated sewage to sea through outfall pipes 1000 to 1300 feet long to deep water. Essential that pipe be tight. Allenhurst laid Universal pipe by means of wheeled skid resting on bottom. Neptune township, near Ocean Grove, used 16-inch galvanized wrought iron pipe screwed together in 20-foot sections with 6-inch screwed couplings. Pipe was assembled on beach and pulled to sea by lighter and winch. Sea anchor and gooseneck were placed by divers.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Muncipal Water Softening. W. C. HIRN and E. F. ELDRIDGE. Public Health (Michigan), **13** (n.s.): 163, June, 1925. Discussion of development of municipal water softening in United States and statements of costs.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Filter Plant and the Public. WALTER A. SPERRY. Public Health (Michigan), **13** (n.s.): 51–58, February, 1925. Experiences and observations

on starting new filter plant in community accustomed to another sort of supply. Publicity as aid to overcoming prejudice and acquainting public with advantages of new supply.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Iodine Content of the Public Water Supplies of New Jersey. LeRoy Forman. Public Health News (N. J.), 10: 164–5, May–June, 1925. None contain much iodine. Range from 0 to 8 parts per billion. It is recommended that more marine food, which is high in iodine, be used.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Vacation Typhoid. Thos. G. Hull. Illinois Health News, 11: 201–4, July, 1925. August, September, and October showed greatest number of typhoid deaths during 5-year period, 1918–22. Vacation typhoid is not just a term. It really occurs. Several epidemics at resorts are cited. Precautions necessary to take the place of protection offered in cities by health authorities are detailed.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

A Chemical Investigation of the Water of Devil's Lake, No. Dakota. G. A. Abbott. Proc. Indiana Acad. Sci., 34: 181, 1924. Water of this lake, containing 15,000 p.p.m. total solids, chiefly Na_2SO_4, NaCl, $MgSO_4$, seemed more toxic to fish than its composition indicated. Careful analysis showed 15 p.p.m. zinc. Experiments on fish using this concentration of zinc killed in 8 hours; controls were unaffected. Source of zinc believed to be leeching of zinc salts from treated railroad ties.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Genesis of the Ohio River. Gerard Fowke. Proc. Indiana Acad. Sci., 34: 81–102, 1924. The Ohio came into being through glacial disarrangement of pre-glacial drainage at and near margin of glacial limits, between Mississippi and Kanawha rivers. Divides between the streams were broken down in escape of ponded waters. Irregularity of course is due to Ohio utilizing beds of a number of these pre-glacial streams.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Analysis of the Thermal Waters of Chaudesaigues, Cantal. Ch. Lormand. Compt. rend., 180: 450–1, February 9, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Influence of the Oxygen Content of Water upon the Respiration of Submerged Plants A. Hee and R. Bonnet. Compt. rend., 180: 457–9, February 9, 1925. Intensity of respiration is not sensibly influenced by variation in oxygen of water, in fresh water algae studied.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Failure of the Bouzey Dam. Vladimir de Belaevsky. Compt. rend., 180: 422–5, February 9, 1925. Failure was due to tearing away of dam and not to shearing stresses.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Remarks upon the Salinity Curve of the Waters on the West Coast of Morocco. A. GRUVEL. Compt. rend., **180**: 681, March 2, 1925. NaCl increases with depth in Mediterranean and Atlantic with less salty water below at 4000 to 5000 meters. Off coast of Morocco chlorine increases with temperature and is inverse of normal. Similar conditions have been found by Prince of Monaco in Gulf of Gascony and near Azores.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

On the Absorptive Power of Agar-agar. JEAN EFFRONT. Compt. rend., **180**: 29–33. January 5, 1925. According to Samec and Ssajevic agar should be looked upon as a sulphuric ether of gelose. Agar absorbs acids, alkalies, and metallic salts; but these may be accounted for in the ash. Nature of agar is considered to be more like a lactone.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Rapid Determination of Sulphuric Acid in Water. L. WANDENBULCKE. Compt. rend., **180**: 515–517, February 16, 1925. Based on property of K_2CrO_4 to precipitate $BaCrO_4$ from $BaCl_2$, and to give an alkaline reaction to methyl red. Bicarbonates, which are also alkaline to methyl red must first be destroyed. As a preliminary, acidify exactly with N/10 HCl: then add a few drops more to bring to pH 4.5 using bromphenol blue. Then take 2500 cc. H_2O under test, and add amount N/10 HCl required as determined above. Add 10 cc. 2 per cent $BaCl_2$ and boil 5 minutes to drive off CO_2. Cool. Add 1 cc. methyl red (0.01 per cent) and add drop by drop 0.7 per cent K_2CrO_4 to end point (yellow). It is necessary to run a blank determination using the same quantities of reagents.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Radioactivity of the springs of several stations in the Alps (Aix les Bains, Calles les Eaux) of the Pyrenees (Bagneres de Bigoire) of Cevennes (Lamalou les Bains, Balaruc les Bains, Les Fumades) and of natural gas of Vegeze (Gard) of Herepian and Gabian (Herault). ROBERT CASTAGNE. Compt. rend. **180**: 510–512, February 16, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Hydrogen-Ion Concentration of Sea Water in its Biological Relations. W. R. G. ATKINS. J. Marine Biol. Assoc., **12**: 717–71, 1922. From Chem. Abst., **17**: 1845–6, May 20, 1923. General description of H-ion concentration, its meaning and methods of determining in sea water given. Conclusions: (1) Salt error of cresol red for sea water of salinity 35 per 1000 is pH 0.18 when determined with Clark and Lubs' standard borate buffer mixtures and compared with McClendon's set as corrected by potentiometer measurements. Measurements are believed to be accurate to pH 0.01. To attain this accuracy indicator must be measured with exactness, not by drops. (2) Sea water may become as alkaline as pH 9.7 as result of very active photosynthesis. This it does in virtue of presence of magnesium salts, since limiting pH value of magnesium carbonate is 10.0, as for magnesium hydroxide. Calcium carbonate as pure calcite gives limiting value of 9.0. (3) pH value below 7.6 in salt water in aquarium tanks denotes abnormal excess of carbon dioxide; at 7.3 symptoms of distress may appear among fishes; and at 7.1 water is foul and bad smelling. Water around seaweed in jar may be as acid as 6.4

Agitation with air removes carbon dioxide and increases pH to 8. (4) In open sea between July and December pH varies between 8.27 and 8.14. April figure was 8.24. Storm, by mixing carbon dioxide with water, may reverse normal gradient. (5) From change in titration value it is estimated that minimum amount of carbohydrate photosynthesized as dextrose is 1 kgm. per square meter of surface between July and December. **Respirable Organic Matter of Sea Water.** Ibid. 772–80. (1) On storing, sea water suffers decrease in pH, change being equivalent to 1.0–3.0 cc. 0.01 N. acid to 100 cc. sea water. Decrease is caused by production of carbon dioxide by organisms. (2) Change corresponding to 1 cc. of acid as above is equivalent to that produced by complete oxidation of 3 mgm. per liter of hexose sugar, which requires 3.2 mgm. per liter of oxygen. This does not agree with usual results for oxygen consumed by alkaline permanganate method. Difference is attributed to respiratory changes taking place during storage which set free much organically combined carbon before oxidation by permanganate has been started. (2) It is probable that change in pH on storing indicates amount of plankton present, assuming absence of sewage. (3) Total amount of carbon, calculated as hexose, which is set free during storage by respiration in sea water 20 miles out from Plymouth is about twice that photosynthesized between July and Dec. **Dibromothymolsulphonephthalein as a Reagent for Determining the Hydrogen-Ion Concentration of Living Cells.** Ibid. 781–3. Brom thymol blue may be used in dilute solution for ascertaining pH of marine organisms. It penetrates slowly, but stained portions remain actively motile. **Hydrogen-Ion Concentration of the Cells of Some Marine Algae.** Ibid. 785–8. **Influence Upon Algal Cells of an Alteration in the Hydrogen-Ion Concentration of Sea Water.** Ibid. 789–91. **Preparation of Permanently Non-Acid Formalin for Preserving Calcareous Specimens.** Ibid. 792–4. Formalin which is permanently non-acid and only slightly akaline (close to pH 9) may be prepared by addition of borax to diluted formalin until bright red is shown with phenolphthalein or slaty blue with thymol blue.—*R. E. Thompson.*

Blue Lead as a Rust Preventative. ANON. Gas-Age-Record, **51**: 301–3, 314, 1923. From Chem. Abst., **17**: 1894, May 20, 1923. Sublimed blue lead is a basic sulphate of lead obtained from fumes produced in smelting galena ore. Tests over period of 6 years gave it a rating exceeded only by basic chromate of lead. Mixed with pure raw linseed oil and not more than 5 per cent by weight of drier, it will form coating with modulus of elasticity far above that required by any deformation due to expansion of metal. One gallon of mixture will cover approximately 800 square feet. It is not affected by heat or cold within range of normal atmospheric conditions nor by sulphur or carbon dioxide present in atmosphere.—*R. E. Thompson.*

Purification of Water. F. DIÉNERT. Compt. rend., **180**: 1228, 1925; Bul. mens. office internat. d'hyg. publ., **17**: 684, 1925. There is a spontaneous underground purification of water by chemical processes in which ferrous and manganous salts take part. It includes the disappearance of dissolved O and NO_3. Such water may also contain H_2S and may be almost or quite sterile. A test may be made by taking 500 cc. of water and 10 grams each FeS and

chalk. After 8 days contact it is sterile. One condition is that the water be of low organic content. Biological purification requires ripening of filters. Submerged filters require a coating of algae, diatoms and bacteria. Non-submerged filters require 60 days to get into shape to remove Bact. coli, 8 days to nitrify NH_3 and 9 days to destroy phenol, according to observations. Such a prepared filter may purify water containing 1 or 2 p.p.m. phenol, an important matter in connection with chlorination.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Sterilization of Water by Ultra Violet Rays. F. Diénert. Ann. d'hyg. publ. indust. et sociale, **10**: 586, October, 1924; Bul. mens. office internat. d'hyg., publ., **17**: 321, 1925. Henderson, Ky., and Wegandotte (Wyandotte ?). Michigan, are reported as American installations. Installations in France are noted at Maromme, near Rouen, and at Jlle sur Sorgues. Monaco also has a plant. 25 to 30 watts per cubic meter is current consumption. It will be necessary to construct a lamp of following characteristics before process will be satisfactory in every way: (1) Automatic lighting without tilting; (2) maximum power developed as soon as lighted; (3) constant and uniform activity of ultra violet rays; (4) non-metallizing of lamp; (5) same intensity of ultra violet light during entire time of functioning; (6) least possible current consumption; (7) operation at high voltage; (8) low price. Bibliography is appended.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

A Bacteriological Study of Soda Water. LeRoy Foreman. Public Health News (N. J.), **10**: 228–230, September, 1925. Duplicate samples were collected. One bottle was tested at once for bact. count and Bact. coli: second one week later. First batch showed such good results that some bactericidal ingredient was sought. Succeeding samples after planting were seeded with 24-hour culture of Bact. coli. 75 per cent of inoculated samples failed to show increase. Blanks with water showed about 500,000 organisms. Acidity as citric acid, solids from immersion reading, dyes used for coloring, and artificial ethers showed no relation to bacterial condition. Total CO_2 was determined. Conclusions were that no single constituent was responsible for condition shown but that CO_2 content was most potent single factor.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Purification of Drinking Water of Surface Origin. O. Pfeiffer. Gas u. Wasserfach, **68**: 470–476, 1924; Bul. mens. office internat. d'hyg. publ., **17**: 556–557, 1925. Magdeburg (Puech-Chabal plant) uses degrossisseurs and sand filters. Chlorine introduced prior to slow sand filtration gave excellent results. Enough chlorine was applied so that samples collected half way through filter bed would give test for free chlorine by KI-starch method.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Eijkman Reaction Negative in a Water Containing Bact. Coli. Groetschul. Centralbl. f. Bakt., **92**: 47, 1924; Bul. mens. office internat. d'hyg. publ., **17**: 557, 1925. Some waters tested by Eijkman process (Dextrose broth planted with water under test and incubated 24 hours at 46°C.) gave no gas

production, but gave positive tests by other methods. Besides the usual causes for error (such as too few organisms, and strains failing to produce gas at 46°C.) failure to produce evident gas is ascribed to reduction of NO_3 to NO_2 by H, and to solution of CO_2 produced.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

On the Control of the Chlorine Apparatus of the Indoor Swimming Pool of Frankfort. Al. Gersbach. Gesundheits Ingenieur, 47: 57, 1924; Bul. mens. office internat. d'hyg. publ., 17: 89–90, 1925. Pool of 750 cu. m. capacity has its water recirculated in 12 hrs. Filters and chlorination to extent of 0.3 p.p.m. Cl are used. After 10 months' recirculation water was as satisfactory as that of a women's pool which was filled weekly but not disinfected. Water is changed more frequently on account of algae which grow in joints of tile flooring although pool is cleaned mechanically daily.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Metropolitan Water Board. 19th Annual Report on the Results of the Chemical and Bacteriological Examination of the London Waters for the Twelve Months ended March 31, 1925. Sir Alexander Houston. Introduction reviews work of water examination department since November 1905. Amongst matters dealt with during past year were chlorination of Thames and New River waters, taste experiments, suspended solids in Thames water during different periods of year, pre-filtration waters, increased rates of filtration using primary rapid sand filters, presumptive B. coli test, 1924–1925 river floods, aids to differentiation of bacterial types, value of permanganate, B. Welchii gastro-enteritis and water supply, condition of Thames as regards dissolved oxygen, resistance to filtration and microscopical appearances of pre-filtration waters, sterilisation of new mains, complaints from consumers, excess lime method, iodine in water, prolonged storage, and meteorological notes. Report is so exhaustive that abstract work cannot do it justice. *Chlorination of R. Thames water.* Structural changes during year introduced new and difficult factors in successful treatment of Thames River supply. Water after chlorination occasionally developed iodoform taste. At such times permanganate plant was put in operation with completely successful results. This plant was put in commission in anticipation of taste occurring in the filtered water. Not a single taste complaint was received from consumers. Permanganate treatment occurred on 18 days during year. During 1924–25, raw water after treatment showed B. coli present in 65.6 per cent of samples in 100 cc. and only 33.1 per cent positive in 10 cc. Figures are higher than in previous years, due to turbid and flood water conditions extending over prolonged periods. Bearing in mind quality of water before treatment results are regarded as very satisfactory. As result of pre-chlorination the "number of acres of filter beds cleaned" has been greatly reduced, figures showing reduction of 31 per cent between 1915 and 1925. In stored waters chlorine is regarded as algicidal, as well as bactericidal agent, but unlike copper sulphate, it is more efficacious for latter purpose. Houston states that "the inhibitory effect of chlorine wears off, and if the water is stored long enough and the reservoir is infected from new or old growths, a further development may

take place." Chlorination of 26,269.4 millions of Thames water was made during year, in which 121.58 tons of bleach, 4.8 tons of liquid chlorine, and 0.13 ton of permanganate were used, at a cost for chemicals of approximately $5900 and a net saving in operating costs of $59,300. Average dose of chlorine applied was 0.43 parts per million. The average percentage of available chlorine extracted from bleach was 37.22 per cent. *Chlorination of New River supply.* In spite of abnormally bad water conditions, New River was successfully treated on 291 days during year, no complaints of taste being received. Very close laboratory control was necessary to achieve this. Average dose of applied chlorine was 0.353 parts per million. Permanganate treatment for taste prevention took place on 281 days when an average dose of 0.21 part was applied. Total cost of chemicals amounted to 45 cents per million imperial gals. of water. treated. *Taste experiments.* Details are given of laboratory experiments on general well at Ferry Lane works upon dilution of water susceptible to taste after chlorine treatment. Dilution as high as 80 per cent untreated mixed with 20 per cent treated water failed to dissipate or obscure taste. Experiments also included chlorination followed by dechlorination with sulfur dioxide. HOUSTON says "It is obvious that the treatment of a water, like the Ferry Lane supply, presents serious difficulties. In order to secure immunity from taste troubles, either costly super-chlorination methods would have to be employed, or the risk run of incomplete sterilisation by resorting to a minor dose of chlorine." The untreated water had a slight earthy taste, which was not appreciably modified by treatment. In no case, however, was there any iodoform taste, in striking contrast to the ADAMS' results, so it is obvious that some waters, at all events, are more prone to taste troubles *after*, as compared with before filtration. It is difficult to say how such a water (water treated with chlorine before filtration) would behave as result of filtration process. Possibly, or probably, earthy taste would be removed and a tasteless water result. On the other hand if there were any latent taste, this might be at first adsorbed in filter bed, and later on become apparent in filtrate. At all events, results are sufficiently striking to lead one to doubt wisdom of unconditionally recommending postfiltration chlorination; indeed it might be argued that they point somewhat strongly to desirability of chlorinating before filtration. *Consideration of Adams's results.* Three pages are devoted to work (English) of ADAMS and of THRESH and BEALE and some twenty-one pages to exhaustive researches by HOUSTON himself. Original article of B. A. ADAMS which appeared in The Medical Officer (England) **33**: 12, 869, entitled "The iodoform taste acquired by chlorinated water" is considered so important that it is reproduced in full. Included in ADAMS's text is statement "It appears to be generally known that this iodoform taste can be imitated by chlorinating a water containing a trace of phenol, but this fact is not widely published, neither are there any details on this point." [In America, where much work has been carried out on chloro-phenoloid tastes, this statement will not be well received. Detailed figures were published in this JOURNAL as far back as 1922 and since that date many others.—ABSTR.] Summary of ADAMS's results: (1) There is some constituent in the atmosphere at certain times and places, which combines with chlorine added to a water and causes iodoform taste. (2) This constituent is probably

of phenoloid character derived from gasworks and from imperfectly burnt coal. (3) This reaction does not take place if water contains a trace of free ammonia. (4) Nor does it take place if chlorinated water is not exposed to air, or if water contains an unusual amount of organic matter. (5) Chlorinated water should not be exposed to air, at least in proximity of towns or gas works, nor afterwards be mixed with water which has been so exposed. Houston who is familiar with much of the American work adds "As regards (4) it would perhaps be better to add after the words 'not exposed to air' the words 'or contaminated with liquids containing phenol bodies.'" Some details of work of Drs. Thresh and Beale on "The taste and odor of chlorinated waters" aré included and summarised as follows: (1) Taste is more persistent than odor. (2) There are marked differences between individuals with reference to taste sensitiveness; women appear to be more sensitive than men. (3) Both men and women could detect taste at a dilution of 1 in 40 millions. (4) The majority (women in this case) could detect it at 1 in 2000 millions. (5) Some could unhesitatingly detect it at 1 in 5000 millions. (6) At 1 in 10,000 millions, no taste could be detected. 37 of Houston's own experiments are given in full; possibly the most complete of their kind ever published. They are summarised as follows:—(1) London air contains substances which, when absorbed by water react with chlorine to produce iodoform taste (see experiment 6). Presence of "particulate" matter does not appear to be essential factor in provoking taste (see experiment 4). (2) Rain water in London may absorb enough of these substances to give, when added to tap water in proportion of 1 per cent, iodoform taste in presence of free chlorine (e.g., experiments 24, 25, and 26). (3) Carbolic acid, in proportion of 1 part to one thousand million parts of water, can, in presence of free chlorine, produce iodoform taste (experiments 27 and 28). Vapours derived from such substances as izal and lysol have strong taste-imparting qualities (see experiments 20 and 21). These experiments also show that if izal-, or lysol-, contaminated air is first passed through alkaline permanganate, its taste provoking quality is practically removed. (4) There are several taste preventers, or taste removers. These include organic matter, potassium permanganate, ammonia and ammonium salts, superchlorination and dechlorination. Light and sunshine have a slight effect in removing iodoform taste from water. Aëration is not of much value. Conclusions drawn are that superchlorination and dechlorination, apart from question of expense, are uniformly successful. The more chlorine that is added, the more certain is absence of taste after dechlorination. Ammonia is a taste preventer, and permanganate both a taste preventer and a taste remover. A diagram (see diagram 1) is given showing the number of pounds of chlorine, sulphur dioxide, permanganate, and nitrogen (ammonia) to be added per million gallons of water treated, to correspond with a wide range of doses, and approximate cost involved in each case. As to which is the best method to adopt when dealing with taste conditions, Houston states "The question cannot be answered satisfactorily. Each case must be judged on its merits. When the circumstances are such that only a short period of contact is possible, the water perhaps seriously polluted and, as well, likely to cause taste troubles, perhaps due to phenol pollutions and relative absence of organic matter as a corrective

factor, and economical considerations are not dominant factors in the situation, superchlorination and dechlorination methods should be carefully considered. In cases when questions of taste are almost certain to arise, the duration of contact adequate, and arrangements as regards scientific supervision satisfactory, the use, in conjunction with chlorine, of permanganate or, ammonia (or its compounds), as taste preventers, should receive special consideration. Permanganate has the advantage of being a taste remover as well as a taste preventer and of assisting sterilisation without producing "lagging" effects. Ammonia apparently causes a "lag" in the sterilisation process, but increases its ultimate effect. Moreover, in the case of waters containing very little oxidisable matter and possessing little or no color, the use of ammonia would seem to present special advantages." *Suspended solids in R. Thames water.* Suspended solids determined gravimetrically weekly. During 12 weeks, total solids were less than 100; during 16 weeks, between 100 and 200; during 12 weeks, between 200 and 300; during 10 weeks, between 300 and 400; and during 2 weeks, between 400 and 500 pounds per million gallons respectively. *Pre-filtration waters.* These are the waters previous to filtration, which have undergone some system of treatment, either sedimentation, resulting in devitilisation or attenuation of pathogenic organisms, rapid filtration, or chemical treatment. The great mass of water was improved 10 times, a goodly proportion of it 100 times, and a small amount actually 1000 times, as judged by B. coli tests. On a proportional basis, number of bacteria in raw water was reduced 85.8 per cent. B. coli figures show 78.3 per cent of raw water positive in 1 cc. or less, while 28.7 per cent of pre-filtration waters contained no B. coli in 100 cc. Chemically, reductions are shown in ammonia and albuminoid nitrogen, oxygen consumed, turbidity, and color. "The loss of vitality of pathogenic microbes has been carefully correlated with certain physical, chemical, and bacteriological changes which occur in river water as a result of adequate storage; so it comes about that by the analysis of the pre-filtration waters, it is possible to deduce a margin of safety previous to filtration. The chemical results in this question, are of real value. It is not merely a question of percentage improvement, but an alteration in ratio; thus the ammoniacal nitrogen, turbidity, and color tests show greater reductions than the albuminoid nitrogen and permanganate tests. It takes time to bring about these changes, and all bacteriologists know the profound influence of time in destroying the vitality of pathogenic bacteria." *Barn Elms experiments.* Brief reference is made to these experiments where nine rapid sand units are in use. It was considered desirable to try the effect of much higher rates of filtration (ordinary rate 120 gallons per square foot per hour), but this for mechanical reasons was found to be impracticable. Four experiments carried out in miniature filters are described and conclusions drawn are: "Apart from questions of quality (not dealt with here), the life between successive cleanings of a filter and the volume of water filtered can be materially increased by the preliminary removal by rapid filtration of most of the growths and much of the suspended matters. . . . . The writer, however, is mainly concerned with questions of quality and although the results of new procedures may possibly lead to the consumer receiving a water less perfect in physical and chemical sense, he is not unprepared to condone these imper-

fections provided always the position is rendered as safe, or safer, bacteriologically and epidemiologically. In this connection, chlorination, or some other form of sterilisation, should be regarded as the supreme factor making for safety. Conceivably, chlorination may only be needed as a stand-by measure, but the necessary plant should undoubtedly be installed and used in connection with the large new schemes looming in the near future, permanently, or until the last shred of doubt of the perfection of the new arrangements has been finally and absolutely established." *Three star* (***) *presumptive B. coli test.* Rapid method for judging quality on bases of presumptive test in 10 and 1 cc. portions. Quality of bile-salt used for this test has been found to be non-selective since the war. Ten cc. and 1 cc. cultures of water are made into double and single strength liquid lactose bile-salt medium respectively. Tubes are placed in warm water (37°C.) for a few minutes, and then transferred to incubator (37°C.). After 24 hours they are examined. If there is gas formation in both tubes sample is considered unsatisfactory, and no further tests made, it being assumed that reasonably pure water would not give positive result within 24 hours with so small an amount as 1 cc. and, further a 1 cc. positive presumptive result probably indicates a 10 cc. confirmatory result. If 10 cc. positive and 1 cc. negative, water is objected to and further procedures carried out. The 10 cc. tube is subcultured into lactose broth and peptone water, indole test being regarded as essentially typical of B. coli. Following is for rapid judging and starring: *Primary cultures.* (*a*) Both tubes negative. Water passed unconditionally. No stars. (*b*) Both tubes positive. Water objected to unconditionally. Three stars (***). *Secondary cultures.* (*c*) Lactose negative, indole negative; and (*d*) lactose negative, indole positive. Water passed provisionally. but question of further samples considered. One star *. (*e*) Lactose positive, indol negative. Water objected to, but not absolutely condemned, two stars, **. (*f*) Lactose positive, indole positive. Water objected to unconditionally. Three stars ***; same as (*b*). Foregoing classification is suggestive merely, and may be modified in great variety of ways to suit particular circumstances, or meet views of individual workers. For example, sets of three, five, or even ten tubes may be employed and conclusions based on number giving positive results, perhaps 2 out of 3, or 3 out of 5, or 6 out of 10. *Aids to differentiation of bacterial types.* Reviews work of Koser on use of a citrate medium as aid to differentiation of members of colon group; also recent conclusions of Brown, Duncan, and Henry (Journal of Hygiene, XXIII, No. 1). Conclusions reached on London waters were, that citrate test would not be of much value in connection with ordinary examination. With "lactose + and indol +" microbes, citrate test yielded negative results, but with some coli-like forms non-typical in character, negative results were also obtained. In general, citrate test confirmed significance of "lactose + indol +" microbes, but sometimes failed to exclude non-typical varieties. Experiments were made during winter months and opinion is expressed that summer results might be different. It is considered that available evidence (Koser's own work) is in favor of citrate test being of considerable value in judging new and doubtful sources of supply, but caution is desirable. Houston considers some bacteriologists a little too eager to deny recognition to aërogenes group because they are apt to be associated with

washings from grains and soils. Yet it is in times of flood when all sorts of 'unchartable' pollutions are swept into watercourses that these soil microbes may be perhaps specially noticeable and few will deny that floods are periods of epidemiological danger. Take case of Poona (India), as example. Before chlorination was practised, advent of flood water was inevitably followed by water borne epidemics of a most serious kind. Presumably at these periods presence of aërogenes group of microbes and such perfectedly harmless soil bacteria as B. mycoides might be considered indicators not of safety, but of danger. Writer ventures to think that bacteriologists should think first of epidemiology. It would be too much to ask epidemiologists to reverse the position. In striving after common sense both schools have a common playground. *B. Welchii, gastro-enteritis, and water supply.* Houston gives interesting discussion on this subject, but sees no reason for changing his views previously expressed, namely, "The B. coli test is still by far the most reliable and speediest method of judging the degree of efficiency of the particular water purification process under investigation, and when a sterilisation treatment is in operation, the certified destruction of B. coli should afford absolute proof, practically speaking of the devitalisation of all the microbes of epidemic water-borne disease." *Resistance to filtration and microscopical appearances of the pre-filtration waters.* These investigations have now been carried out for past ten years and have been of great operating value. Apart from special photographs, over 11,000 routine photographs have been taken of suspended matter in the water, showing a permanent record of condition of pre-filtration waters from both qualitative and quantitative points of view. Diagram at end of report gives averages for ten years ending March, 1925. *Under the heading of miscellaneous are included variety of subjects. Sterilisation of new mains.* The importance of sterilising new water mains greatly in excess of the normal dose is emphasized. *Complaints from consumers.* All complaints are investigated regardless of distance. Interesting details of one complaint in very old house are given. In this instance the service became infested with minute worms (oligochaetes). No other complaints were discovered in neighbourhood. The drastic remedy of chlorinating whole system of supply in house in question was successfully carried out. Subsequent visits showed that treatment had been completely satisfactory. (Photographs nos. 204 and 205.) *Excess lime method.* Mention is made as to the success in India of this method for destroying cyclops in water: this crustacean being supposed to act as the intermediary host in the development and transmission of guinea-worm embryos to man. Chlorine in permissible doses was not found so useful. *Iodine in water.* Reproduction is made of valuable article which recently appeared in The Medical Officer (England) No. 869. Report concludes with valuable meteorological observations. Ten diagrams covering various conditions arising in the purification and operation are included. Many beautiful photographs are reproduced. Statistics of London supply include the following: Storage reservoirs number 49, cover 2704 acres, and hold 19,657 million imperial gallons. 91 service reservoirs cover 91 acres and hold 322.7 million gallons; 172 filter beds cover 170.7 acres, filter at rate of 2 gallons per square foot per hour. Engines number 274 of total horse power of 44,278. There are 6.725 miles of water mains. Average daily supply is over 250 million

gals. supplying over 7 million people, with per capita consumption of approximately 37 gallons. Eighty per cent of supply is from rivers and 20 per cent from deep wells. Report is most valuable of its kind that is published and contains much new and practical information.—*N. J. Howard.*

Importance of Differentiating Colon-Aërogenes Group in Examining Water. Jack J. Hinman, Jr. Am. J. Pub. Health, 15: 614–9, July, 1925. (Reprint.) General discussion of test for B. coli in water, with special reference to present status of methods for differentiation of colon-aërogenes group and value of information derived therefrom. Author believes that while these methods have definite investigational value, development of subject is not such as to justify attaching too great significance to division of group into-so-called fecal and non-fecal types. Method of differentiation recommended in Standard Methods (A. P. H. A.) is not practical for ordinary routine examination, as time required is prohibitive, results having only historical value when tests are completed. Tabulation of results of examinations of treated water from Iowa plants during 1914–1924 inclusive given, showing that of 18,847 tubes planted, 31.5 per cent gave postive presumptive tests, 9.4 per cent of these being due to presence of *B. coli*, 9.8 per cent to *B. aerogenes*, and 80.8 per cent to other gas formers.—*R. E. Thompson.*

Sodium Hypochlorite. Science, 62: xiv, September 18, 1925. Jean Perrin, before Academy of Sciences, quotes experiments carried out by Philippe Bunau-Varilla and Emile Techoueyre to prove or disprove their theory that germicidal power of sodium hypochlorite is due to germ-destroying invisible rays given off when in contact with organic matter. Quartz tube was filled with dilute solution of sodium hydpochlorite and placed within larger quartz tube, interspace filled with water containing B. coli and whole immersed in hypochlorite solution. Parallel experiment, omitting the disinfectant, was also carried out, and after standing 24 hours water from each was examined by plating on gelatin. In 51 of 60 such experiments, water exposed to hypochlorite solution contained lower number of bacteria.—*R. E. Thompson.*

Rôle of Carbon Dioxide in Corrosion of Iron. T. Fujihara. Chem. and Met. Eng., 32: 16, 810–1, October, 1925. Experiments were conducted to prove that pure water and pure oxygen cannot attack iron on which a protective film has been previously produced, the additional action of carbon dioxide being necessary to produce rust. Other tests were conducted to show that rusting once started will cease if carbon dioxide is excluded. Carbon dioxide plays an important part in corrosion process, but its action is entirely different from that claimed by many investigators. Initial reaction is electrochemical and the carbonic acid later combines with the ferrous hydroxide.—*John R. Baylis.*

A Device for Estimating Corrosion. W. R. Fetzer. Ind. Eng. Chem., 17: 788, August, 1925. Description of equipment used in determination of corrosiveness of various liquids toward metals, etc.—*Linn H. Enslow.*

Fundamental Factors in Corrosion. GEO. M. ENOS. Ind. Eng. Chem., **17:** 8, 793, August, 1925. Tendency for a metal to corrode is simply its tendency to lose electrons. Atoms are composed of positive and negative charges of electricity (electrons). Ions are produced when an atom or combination of atoms (molecules) lose one or more electrons. Atoms of metallic iron (Fe^0) lose two negative electrons to produce positively charged ions of ferrous iron (Fe^{++}) which in turn lose another negative electron to produce ferric iron (Fe^{+++}). The negative electrons split off neutralize positive charges on hydrogen ions—atomic hydrogen (H^0) resulting: thus (1) $Fe^0 + 2(H^+ \cdot OH^+) = Fe^{++}: (OH^-)_2 + 2H^0$; and (2) $Fe^{++}: (OH^-)_2 + H^+.OH^-) = Fe^{+++}: (OH^-)_3 + H^0$. Considered in this light, it is apparent that the oxidation and electrochemical theories agree basically. In tests made on various mild steels there appears to be no relationship between carbon content and rate of corrosion in air or distilled water. Rate of corrosion in air appears to be about 10 times that in distilled water. Rate of corrosion increased in all cases with temperature; rate of increase in cases of dilute sulphuric acid, ferrous sulphate, and distilled water being relatively of same intensity over given temperature range. Difference between extent of corrosion in daylight and that in darkness was inappreciable in tests made. There was indication, however, that light accelerates corrosion to some extent.—*Linn H. Enslow.*

Permanent Standards as Possible Source or Error in Iron Determinations. EDWARD S. HOPKINS. Ind. Eng. Chem., **17:** 8, 832, August, 1925. Permanent iron standards prepared in accordance with proceedure outlined in Standard Methods of the A. P. H. A. give erroneous results. In extreme cases they may indicate only 50 per cent of true quantity of iron present in sample. Error varies between 0.002 and 0.15 mgm. of iron (Fe). Extent of error increases with increase in value represented by the artificial standards. A great deal also depends upon quality and shape of tubes used for the comparison. In all cases, for accuracy permanent standards should be calibrated, or finally standardized against series of solutions of known iron content. [It is essential to follow empirical formulae and use exactly sizes and shapes of tubes recommended in Standard Methods for accurate results. Comparative data presented in article indicate that results of sufficient accuracy were obtained when using 50 cc. Nessler tubes as designated in Standard Methods. Errors appeared when departing from empirical procedure always required to produce artificial permanent standards which are to prove accurate.—ABSTR.] —*Linn. H. Enslow.*

A Study of the Chemical Differentiation of Bacteria. ESTHER W. STEARN and ALLEN E. STEARN. J. Bact., **10:** 1, 13 January, 1925. Oxidizing agents alter properties of bacteria usually considered as characteristic of a strain. Constituents of media will also react on bacteria, changing their characteristics. In some instances, variation practically amounts to production of a new strain. After 5 months culturing, four different members of B. coli group exhibited identical cultural characteristics. It seems that a change in environmental conditions results in a change not only in chemical constitution of bacteria, but also in characteristics by which they are classified. If previous

history of such altered strains were not known, they might be classified differently after alteration from what would have been the case with fresh strain.—*Linn H. Enslow.*

The Reducing Properties of Microörganisms with Special Reference to Selenium Compounds. Victor E. Levine. Jour. Bact., 10: 3, 27, May, 1925. Selenium dioxide, or sodium selenite, in concentration 1:50,000 or 1:25,000 can be used to demonstrate bacterial reduction in solid sugar-free culture medium. Selenium compounds serve as better indicators for reducing enzymes than organic dyes inasmuch as the reduction to free selenium is an irreversible reaction. Brick red streak follows line of growth of reducing organisms. Selenium agar (0.15 per cent Na_2SeO_3) as culture medium for selective growth of typhoid bacilli is superior to malachite green or Endo agar.—*Linn H. Enslow.*

Adjustment of pH of Culture Media under Sterile Conditions. Leo M. Christensen and Ellis I. Fulmer. Ind. Eng. Chem., 17: 935, September, 1925. Description and illustration of required apparatus for applying sterile acid or alkali to sterilized media. Its use eliminates necessity of re-sterilization with attendant change in pH value usually encountered in sterilization after adjustment.—*Linn H. Enslow.*

Sulfite Liquor as a Protective Colloid. E. C. Bingham, G. F. Rolland, G. E. Hilbert. Ind. Eng. Chem., 17: 952, September, 1925. Sulfite liquor from pulp industry is very efficacious as a producer of emulsions difficult to flocculate. Alum to which alkali had been added was itself deflocculated upon addition of sulfite liquor. No good flocculating agent has been found for suspensions of clay, etc., in sulfite liquor. Added to water or soap solutions, it lowers the surface tension materially.—*Linn H. Enslow.*

Device for Maintaining a Small Constant Flow of Liquid. Chas. Van Brunt. Ind. Eng. Chem., 17: 966, September, 1925. Feeding orifice consists of shallow helical groove of about ten turns around rod which fits snugly in cylinder. Cylinder is stationary; rod is kept rotating in direction which would force solid particles through in like manner to screw conveyer. By this feature clogging is prevented. Exact adjustment of rate of flow is easily secured by moving rotating shaft or fixed cylinder in or out to change number of threads which are operative. Ordinary machine threads are satisfactory if sharp edges are removed in lathe. In cases of corrosive liquids, hard rubber or graphite may be employed.—*Linn H. Enslow.*

Influence of Curvature on Air Saturation of Water and Its Relation to the Air-Binding of Filters. John R. Baylis. Ind. Eng. Chem., 17: 974, September, 1925. Water under pressure which contains sufficient air to produce atmospheric supersaturation will not upon release of pressure contain visible air bubbles until agitated. Water fairly heavily charged with air exhibits milky appearance when drawn from faucets when emerging stream is exposed to atmosphere. By simply submerging faucet outlet when drawing the water,

milkiness is suppressed: thus indicating necessity of aërial contact with emerging stream for release of dissolved air. Considerable supersaturation (probably over 100 per cent) is required to start release of air bubbles on solid surfaces. Were it not for the few air bubbles entrapped with suspended coagulum in water being filtered, there would be little or no danger of air release from supersaturated water in the beds which results in "air-binding." Air bubbles introduced with wash water and not completely displaced from bed during washing are sufficient to start air release from water during subsequent filtration. Once this release is started, air-binding increases very rapidly if supersaturated water is being handled. In design of filter plants great care should be taken to minimize opportunity for supersaturation prior to filtration. More particularly should possibility of entrained or trapped air bubbles reaching filters be prevented. Entry of air with wash water is particularly to be guarded against.—*Linn H. Enslow.*

Advantages of the Use of Lime in Water Softening and Purification. Charles P. Hoover. Water Softening, Published by the National Lime Association, p. 3. Advantage of adding lime to hard magnesium water are as follows: (1) Water is softened; (2) intestinal and pathogenic bacteria are killed; (3) water is clarified; (4) color is removed; (5) corrosion of iron pipes is prevented and trouble from "red water" is eliminated; (6) sterilizing action of lime persists indefinitely, and (7) nothing in reality is added to the water that was not originally there. Experiments in sterilization by softening with lime at Lawrence, Cincinnati, London, Columbus and other Ohio plants are recounted. Average turbidity of 63 in river water at Columbus for 1910, 11, and 12, was reduced to less than 5 p.p.m. after addition of lime, soda-ash and alum, and allowing 12 to 15 hours settling. Advantage of excess ilme treated water, for swimming pools, over water sterilized by hypochlorite or chlorine, is that disinfecting action of caustic persists, and if the water should become contaminated with pathogenic organisms they will soon become attenuated and finally die because of the absence of carbonic acid in the water. Results of carbonization of softened water at various plants have shown that lime softening is entirely practical and economical.—*A. W. Blohm.*

The Cost of Impurities in Locomotive Water Supply and the Value of Water Treatment. C. H. Koyl, R. C. Bardwell, W. M. Barr, O. W. Carrick, R. W. Chorley, R. E. Coughlan, B. W. DeGeer, J. P. Hanley, W. H. Hobbs, P. M. LaBach, O. T. Rees, H. H. Richardson, D. A. Steel, C. P. VanGundy. Water Softening, Published by the National Lime Association, p. 3. Operation of the railroad depends on the locomotive, and efficiency of the locomotive depends principally on the character of the feedwater. A water of 12 to 15 grains per gallon of incrusting solids, is likely to injure the operation of a road to the amount of $2000 per locomotive per year; and the cost rises with the increase of impurities to practically prohibitive figures at $20,000 to $25,000 per locomotive per year. Installation of water softening plants and the savings following their installations for the Wabash Railway; Chicago & Alton; Hocking Valley; Missouri-Kansas-Texas; Illinois Central; Chicago, Milwaukee & St. Paul and the El Paso and Southwestern railroads are presented.—*A. W. Blohm.*

Raw Water Ice—How A Water Analysis Tells the Quality of Ice You Will Make. A. S. Behrman and O. A. DeCelle. Water Softening, Published by the National Lime Association, p. 3. A brief explanation of the physical and chemical characteristics of water, a tabulation showing the minerals in water, their effect in ice, and the result of treatment with hydrated lime and allowable limits of various minerals are given.—*A. W. Blohm.*

What to Expect from Your Water Treating Plant. A. S. Behrman. Water Softening, Published by the National Lime Association, p. 36. The object of water softening is to make better ice and more ice. Two requirements for really satisfactory chemical feed are that lime mixture be absolutely uniform and that it be fed in strictly accurate proportion to the water being treated. Simple chemical tests on treated water should be made frequently, and the indication of the tests followed. Instances are given where faulty operating conditions were responsible for inferior ice and where water treatment unjustly received the blame.—*A. W. Blohm.*

Some Variants from Accepted Formulae in Water Flows. C. Arthur Brown. Water Softening, Published by the National Lime Association, p. 40. Formulae for determining pipe sizes, volume and velocity of flow and discharge through mains and orifices, with examples showing their practical application.—*A. W. Blohm.*

Severe Leak in Victoria's Concrete Water Main Controlled by Flexible Joint. F. M. Preston. Cont. Rec., 39: 46–8, January 21, 1925. Water supply of Victoria is obtained from Sooke Lake through 27¼ miles of 42-inch concrete pipe flow line and 10½ miles of 36-inch riveted steel pressure pipe. Pipe line was completed in 1915 and by 1918 at least 1200 expansion cracks, almost entirely at joints, had developed in concrete section, giving rise to leakage which in December 1919 was as great as 89 per cent, one per cent loss representing 200,000 gallons per day. Fact that pipe line would deliver nearly 3 times amount of water required made situation less serious than it appeared. Repair work was commenced in 1922, 132 joints being placed, average leakage for year being 48 per cent. In 1923, 240 joints were constructed and average leakage was 30.7 per cent, and in 1924, 200 joints were made and leakage averaged 25.5 per cent. There are approximately 700 joints yet to be repaired. Flexible joint was evolved which could be applied to outside of pipe while water was flowing, consisting of 24-ounce copper strip rolled to fit circumference of pipe and extending two-thirds around it, practically to high level water mark in pipe. Strip is 4¾ inches wide and has V-shaped depression, ½ inch deep and ¾ inch wide, formed longitudinally on centre line, and it is attached to pipe with V projection entering into small groove chipped in offending joint, being clamped into place by two 2½-inch round steel rods and turnbuckles. Two 1¾-inch strips of sheet lead form packing material between copper and concrete. To prevent ice formation in space provided for V, this cavity is first filled with putty of castor oil, asbestos fibre, and red lead, which maintains its consistency all year round. Cost of joints in 1924 was as follows: Copper $3.70, lead $1.60, clamps $1.79, putty $1.65, labor $5.92, total $14.67.—*R. E. Thompson.*

Tunnel under Lachine Canal, Montreal. Cont. Rec., 39: 53, January 21, 1925. Tunnel under construction which will join two vertical shafts sunk from surface through approximately 70 feet of quicksand and 30 feet of rock, described briefly. Tunnel, which is 14 feet by 15 feet in section, will carry three riveted steel mains, two 36-inch and one 48-inch, to supply section of Montreal north of canal, which is at present supplied by two 36-inch cast iron pipes laid in bed of canal. Concrete linings will be placed by pneumatic method.—*R. E. Thompson.*

An Interesting Water Works Valve Equipment for Australia. Cont. Rec., 39: 770, August 5, 1925. Brief illustrated description of two 36-inch cast iron Johnson-Boving control valves, weighing 5 tons each, supplied to Sydney water works, New South Wales, for operating at head of 200 feet.—*R. E. Thompson.*

State Grants for Rural Sewage and Water Works. A. J. Redfern. Munic. Eng., 75: 687, June 25, 1925. Conditions relative to sewage disposal and water supply in rural districts in Great Britain reviewed and financial difficulties discussed. Government grants for relief, through Ministry of Health, advocated.—*R. E. Thompson.*

The Properties of Aluminate Cement. Roger L. Morrison. Cont. Rec., 39: 417–8, 1925. Tests of properties of American aluminate cement (Atlas Lumnite Cement Company) indicated that maximum strength is reached in 3 to 5 days, strength of 1:2:4 aluminate cement concrete at 5 days being almost twice that of best 1:2:4 portland cement concrete at 29 days. At 29 days a 1:4:8 aluminate cement concrete has approximately same strength as 1:3:6 portland cement concrete, while 1:3:6 aluminate is approximately as strong as 1:2:4 portland. In practically all cases, strength of aluminate concrete was inversely proportional to the amount of water used. Amount of water required to produce a given slump with aluminate cement was practically same as with portland cement. In almost every case cylinders cured in dry air were stronger than those cured in moist air, the average difference in strength being 7 per cent. An average of 209 pounds per square inch was required to break at end of 24 hours 6 cylinders made by replacing in molds half-briquettes of portland cement and filling rest of space with aluminate cement mortar. Results of setting time tests made upon mixtures of aluminate and portland cements showed that flash set does not occur unless proportion of portland cement falls between 33 and 90 per cent.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Condensers of Atmospheric Vapor Supplied Water to the City of Theodosia in Tauride (Crimea) Five Centuries before the Christian Era. Anon. L'Eau, 18: 92–93, 1925. Russian engineers working on water supply for modern town discovered water system leading to springless mountain tops. Investigation disclosed large condensers made of piles of stone 25 meters long, 30 meters wide and 10 meters high. There were thirteen of these in a space of 3 km.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Spread of Dysentery Considered from the Aspect of Public Health. PHILIP MANSON-BAHR. J. State Med., 33: 401–414. 1925. Flies, water, and carriers are considered as vectors of infection. Emphasis is placed on carriers in case of bacillary dysentery and on water in case of amœbic dysentery.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

East Durham Water for Boiler and Other Purposes. W. GORDON CAREY. Chem. Ind., 44: 286–290T, 1925. General paper on softening of hard magnesian waters by various methods and including discussion of removal of oil and dissolved gases. Wells 140 to 500 feet deep are source from which 10 m.g.d. are derived. Sanitary quality is good.—*Jack J. Hinman, Jr.*

Report of Measures for the Protection of Underground Waters. A. R. ATKEY, ALFRED B. E. BLACKBURN, A. E. CORNEWELL-WALKER, FRED W. MACAULAY and WM. TERR. Water and Water Eng., 27: 175–180, 1925. Report of sub-committee to Advisory Committee to Ministry of Health of Great Britain concerning legal rights of property holders in underground waters. **Protection of Underground Water.** PERCY GRIFFITH, Ibid., 27: 196–8, 1925. Discussion of above report.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

NEW BOOKS

Regulation of Rivers Without Embankments. As Applied in the Training Works at the Headwaters of the Rangoon River, Burma. (Locally known as the Myitmaka Training Works.) F. A. LEETE and G. C. CHEYNE. London: Crosby Lockwood and Son; New York: D. Van Nostrand Co. 122 pp. $12.—*R. E. Thompson.*

Public Health in Theory and Practice. WM. HENRY WELCH. New Haven, Conn.: Yale University Press; London: Humphrey Milford, Oxford University Press. Cloth; 5 x 8 inches; pp. 51. $1. Reviewed in Eng. News Rec. 95: 108, July 16, 1925.—*R. E. Thompson.*

The Public and Its Utilities. WM. G. RAYMOND. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd. Cloth; 6 x 9 inches; pp. 346; appendix of operating expense tables, and amortization tables. $3.50. Reviewed in Eng. News Rec. 95: 109, July 16, 1925.—*R. E. Thompson.*

The Water Supply of Buildings and Rural Communities. WALTER S. L. CLEVERDON. New York: D. Van Nostrand Co. Cloth; 5 x 8 inches; pp. 186; appendix of 23 charts and tables. $2.50. Reviewed in Eng. News Rec., 95: 110, July 16, 1925.—*R. E. Thompson.*

The Principles of Public Health Engineering. EARLE B. PHELPS. New York; The Macmillan Co. Cloth; 6 x 9 inches; pp. 265; $3. Reviewed in Eng. News Rec. 95: 111, July 16, 1925.—*R. E. Thompson.*

The Transactions of the First World Power Conference, London, June 30 to July 12, 1924. Volumes I to IV. London: Percy Lund Humphries and Co., Ltd. Cloth; 7 x 10 inches; pages as follows: Volume I–1506, II–1599, III–1502, IV–1816; index in separate volume. Four volumes £10; index £2; both in London. Reviewed in Eng. News Rec. **95:** 110, July 16, 1925.—*R. E. Thompson*

Construction Plant, Methods and Costs: The Miami Conservancy District. CHAS. H. PAUL. Technical Reports, Part X. Dayton, Ohio: The Miami Conservancy District. Paper; 6 x 9 inches; pp. 411. $2. Reviewed in Eng. News Rec., **95:** 315, August 20, 1925.—*R. E. Thompson.*

Effective Regulation of Public Utilities. JOHN BAUER. New York: The Macmillan Co. Cloth; 5 x 8 inches; pp. 381. $2.50. Reviewed in Eng. News Rec. **95:** 316, August 20, 1925. *R. E. Thompson.*

Practical Water Engineering. W. T. TAYLOR. Crosby Lockwood and Son. 270 pp. 36s., by post 36s. 9d. Reviewed in Munic. Eng., **76:** 9, July 2, 1925.—*R. E. Thompson.*

River Gauging: A Report on Methods and Appliances Suitable for Use in Great Britain. M. A. HOGAN. H. M. Stationery Office. 70 pp. 2s. 6d., by post 2s. 9d. Reviewed in Munic. Eng. **76:** 59, July 16, 1925. *R. E. Thompson.*

A Bibliography of Bibliographies on Chemistry and Chemical Technology, 1900–1924, by CLARENCE J. WEST AND D. D. BEROLZEIMER, is announced by the National Research Council, Washington, D. C., as their Bulletin No. 50 (308 p., $2.50). This work is composed of the following sections: General Bibliographies, Abstract Journals and Year-Books, General Indexes of Serials, Bibliographies of Special Subjects and Personal Bibliographies. As the title indicates, the work is a compilation of bibliographies published as separates, or at the end of books or magazine articles, or as footnotes to the same, on the numerous aspects of pure and applied chemistry. Each entry gives name of author or compiler, title, and place of publication. The majority of the entries state the number of references, thus giving an indication of the completeness of the particular bibliography. The entries are classified under the proper subject headings, alphabetically arranged. The duplication of individual entries has been largely avoided by the liberal use of cross-references. An approximate analysis shows that there are about 2400 subject headings, 7500 author entries and a total of 10,000 individual bibliographies. Although no claim is made for the completeness of the compilation, it is believed that the work will furnish a convenient starting point for any bibliographic search.

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

VOL. 15 MARCH, 1926 No. 3

CONTENTS

OFFICERS OF THE AMERICAN WATER WORKS ASSOCIATION

President

HARRY F. HUY. General Manager, Western New York Water Co., 704 Electric Building, Buffalo, N. Y.

Vice-President

GEORGE W. BATCHELDER, Water Commissioner, 19 City Hall, Worcester, Mass.

Treasurer

WILLIAM W. BRUSH, Deputy Chief Engineer, Division of Water, Department of Water Supply, Gas and Electricity, Municipal Building, New York, N. Y.

Secretary

BEEKMAN C. LITTLE, Superintendent Water Works, 43 City Hall, Rochester, N. Y.

Editor

ABEL WOLMAN, 16 West Saratoga Street, Baltimore, Md.

Trustees

Term expires 1926	Term expires 1927	Term expires 1928
E. E. WALL St. Louis, Mo.	J. ARTHUR JENSEN Minneapolis, Minn.	R. L. DOBBIN Peterborough, Ont.
C. R. BETTES Far Rockaway, L.I., N.Y.	EDGAR M. HOOPES, JR. Wilmington, Del.	GEORGE H. FENKELL Detroit, Mich.
JAMES E. GIBSON Charleston, S. C.	FRED MORSE RANDLETT Portland, Ore.	PATRICK GEAR Holyoke, Mass.

Executive Committee.—HARRY F. HUY, GEORGE W. BATCHELDER, GEORGE W. FULLER, FRANK C. JORDAN, the Treasurer, the Secretary, the Editor, the nine Trustees, and the Chairman of the Finance Committee.

Finance Committee.—GEORGE C. ANDREWS, Chairman; HENRY P. BOHMANN, E. G. WILHELM.

Publication Committee.—MALCOLM PIRNIE, Chairman; A. M. BUSWELL, W. S. CRAMER, W. W. DEBERARD, JOHN M. GOODELL, NICHOLAS S. HILL, JR., F. C. JORDAN, B. C. LITTLE, JAMES J. SALMOND, STEPHEN H. TAYLOR, ABEL WOLMAN.

Officers of the Divisions

Water Purification Division.—Chairman, JAMES W. ARMSTRONG; Vice-Chairman, MACHARVEY MCCRADY; Secretary, H. E. JORDAN; Executive Committee, A. M. BUSWELL, W. H. LOVEJOY, RICHARD MESSER.

Fire Protection Division.—Chairman, NICHOLAS S. HILL, JR.; Vice-Chairman, ALLAN W. CUDDEBACK; Secretary-Treasurer, CLARENCE GOLDSMITH.

Plant Management and Operation Division.—Chairman, J. E. GIBSON; Vice-Chairman, DOW R. GWINN; Secretary-Treasurer, GEO. C. GENSHEIMER; Trustees, W. S. CRAMER, ALEXANDER MILNE.

Officers of the Sections

California Section.—Chairman, C. B. JACKSON; Vice-Chairman, SAMUEL B. MORRIS; Secretary-Treasurer, PAUL E. MAGERSTADT; Executive Committee, JOHN BURT, P. DIEDERICH, and the officers.

Canadian Section: Chairman, C. D. BROWN; Vice-Chairman, R. H. STARR; Secretary-Treasurer, A. U. SANDERSON; Trustees, D. MCL. HANNA, J. O. MEADOWS, W. C. MILLER; Immediate Past Chairman, N. R. WILSON.

OFFICERS OF THE
AMERICAN WATER WORKS ASSOCIATION (Continued)

Central States Section.—President, JOSEPH W. ELLMS; Vice-President, CHESTER F. DRAKE; Secretary, E. E. BANKSON; Trustees, J. C. BEARDSLEY, D. C. GROBBEL, MENTOR HETZER.

4-States Section.—President, EDGAR M. HOOPES, JR.; Vice-presidents, V. BERNARD SIEMS, L. VAN GILDER; Secretary-Treasurer, CHARLES R. WOOD; Executive Committee, N. E. BARTLETT, W. H. BOARDMAN, H. D. BROWN, J. W. LEDOUX, GEORGE McKAY, and the officers.

Illinois Section.—Chairman, W. R. GELSTON; Vice-Chairman, G. C. HABERMEYER; Treasurer, H. E. KEELER; Trustees, H. M. ELY, L. R. HOWSON, C. M. ROOS,

Indiana Section.—Chairman, J. O. ENDRIS; Vice-Chairman, WM. LUSCOMBE; Secretary-Treasurer, C. K. CALVERT; Assistant Secretary-Treasurer, B. J. T. JEUP.

Iowa Section.—Chairman, HOMER V. KNOUSE; Vice-Chairman, J. W. McEVOY; Secretary-Treasurer, J. J. HINMAN, JR.; Directors, THOS. J. SKINKER, C. D. HAYS.

Kentucky-Tennessee Section.—Chairman, C. E. DAVIS; Vice-Chairman, W. S. PATTON; Secretary-Treasurer, F. C. DUGAN; Directors, F. W. ALBERT, W. H. LOVEJOY.

Minnesota Section.—Chairman, J. A. CHILDS; Vice-Chairman, FELIX SELIGMAN; Secretary-Treasurer, ARTHUR F. MELLEN; Trustees, OLE FORSBERG, A. D. HORNE, E. McCULLOH.

Montana Section.—J. F. WILLETT, President; H. B. FOOTE, Secretary-Treasurer.

New York Section.—President, B. B. HODGMAN; Secretary, E. D. CASE; Board of Governors, E. D. CASE, B. B. HODGMAN, F. T. KEMBLE, THADDEUS MERRIMAN.

North Carolina Section.—President, J. O. CRAIG; Vice-President, M'KEAN MAFFITT; Secretary-Treasurer, THORNDIKE SAVILLE; Executive Committee, G. F. CATLETT, E. G. McCONNELL, H. E. MILLER, A. O. TRUE, W. E. VEST, and the officers.

Wisconsin Section.—Chairman, W. D. LEONARD; Vice-Chairman, EDWARD BROWN; Past Chairman, L. A. SMITH; Secretary-Treasurer, C. M. BAKER; Director, WILLIAM KOEHN.

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

VOL. 15 MARCH, 1926 No. 3

BALTIMORE CITY WATER DEPARTMENT MEETS EMERGENCY DURING DROUGHT OF JUNE, 1925[1]

BY V. BERNARD SIEMS[2]

Notwithstanding the fact that 20 billion gallons of water were impounded behind our dam at Loch Raven (Gunpowder River) Maryland, from which the City draws its water supply through a tunnel capable of delivering 240 million gallons per day; notwithstanding a filtration plant capacity of 128 million gallons, plus 15 per cent overload and an average daily consumption which did not exceed 122 million gallons for the entire City, the service was seriously hampered and the public in certain sections inconvenienced by inadequate pressure during the drought of the recent season.

The month of June, 1925, was marked by a period of extreme drought and excessively high temperatures, continued for such a record-breaking length of time that the local branch of the United States Weather Bureau stated in a review of the conditions that "it was unlikely another such month would be experienced in Baltimore in a century." From June 1 to June 22, the mean temperature was almost 8 degrees above normal and on thirteen days during this period the maximum temperatures were 90 degrees or more. The last week in May and the first three weeks in June had a total rainfall of only 0.27 inch. This combination of high temperatures

[1] Presented before the New York Section meeting, September 26, 1925.
[2] Water Engineer, Baltimore, Md.

and prolonged dry weather was an ideal one for imposing the maximum possible demand upon a water supply system.

The results of these conditions were immediately reflected in the water consumption, particularly in the closely populated suburban sections lying in the northern and northwestern portions of the City. Much of this territory was included in that annexed to the City in 1918, and was formerly supplied by private water companies whose distribution systems had already grown inadequate to meet the demands for domestic consumption. As this section was most suitable for suburban development its growth was very rapid, but had been anticipated by the Department in the construction of an additional 20 million gallon 3rd Service Zone Reservoir at Pikesville and in the rehabilitation of the distribution systems of the private water companies, and the construction of additional feeder mains.

However, all of this work has not yet been completed and, moreover, large additional areas have been added to the distribution system through the establishment of the Baltimore County Metropolitan District, so that, while the Department would have been able ordinarily to have rendered satisfactory service during the summer months, the extreme weather experienced this year brought about a condition which rendered the water service difficult to maintain.

The increase in the water consumption of the districts mentioned was not of serious proportions when viewed on a twenty-four hour basis, being approximately twenty per cent for the Eastern 3rd Service Zone and twenty-five per cent for the Western 3rd Service Zone, but the peak demand that these two districts created in the early evening hours taxed our pumping equipment to its limits and the distributing facilities far beyond their capacities. In the northwestern district, the Western 3rd Service Zone, between 7:30 and 8:30 p.m. the demand for water was often more than 300 per cent of the normal average consumption, and the peak demands in the Eastern 3rd Service Zone were not much less than this figure. Under these conditions, it was not surprising that a considerable portion of the territories using this excessive quantity of water suffered from a lack of adequate pressure at the time of maximum draft, although I am happy to be able to state that no area was completely out of water at any time.

For two months previous to June 1, 1925, the Pikesville Reser-

voir, on which the Western 3rd Service Zone is balanced, was out of service undergoing repairs and it was just starting to be filled when the hot spell unexpectedly came upon us. The first five days of June, with an average maximum temperature of 96 degrees, were sufficient to deplete the reserve that had been accumulated and for the remainder of the period of maximum consumption, the water that was available from this source was only that which we were able to pump into the reservoir in excess of the consumption during the early morning and forenoon hours. In the Eastern 3rd Service Zone part of the system is balanced on a standpipe which has long since been outgrown by the consumption requirements of the district it serves, so this service was no better situated with reference to a reserve than was the Western 3rd Service Zone.

Both the Western and Eastern 3rd Service districts are normally supplied by the Druid Pumping Station, which takes suction from the Pimlico Reservoir at which the station is located.

This reservoir, which was constructed about 1880, is of about 25± million gallons capacity and at that time was used to furnish the 3rd Service Zone to the then small area within the limits of the 1888 Boundary Line needing it. With the gradual increase of consumers in the Western 2nd Service this lake became inadequate and Lake Ashburton, or the Western 2nd Service Reservoir, was constructed as the main supply for the zone, leaving Pimlico Reservoir to serve merely as suction for the pumps at Druid Pumping Station, supplying both Eastern and Western 3rd Service Zones.

The draw on Pimlico Reservoir caused by the excessive pumping demands was greater than the carrying capacity of the 30-inch supply main to the reservoir, resulting in the reservoir water level being drawn down so low as to necessitate throttling the discharge of the Western 3rd Service pumps to the point where the pumpage was no greater than the quantity of water flowing into the reservoir.

Apparently only 8 or 9 million gallons a day could be forced into Lake Pimlico; even with Mt. Royal or Western 2nd Service Pumping Station working at a 30 million rate it steadily lost water.

This limitation was a serious handicap to the pumpage, as we were not able to operate these pumps to their capacity, and in order to alleviate this condition changes were made in the distribution system to throttle the flow to Ashburton, or Western 2nd Service Zone Reservoir, and thus force more water into Pimlico Reservoir. In addition a 16-inch main into Pimlico, which had

been shut off from this reservoir for a number of years, was placed back in service. These manipulations improved conditions somewhat, but there was still a deficiency in the flow to Pimlico Reservoir, as is shown by the fact that the maximum permissible quantity drawn from the reservoir in any one day during the period under discussion was 11.27 million gallons, whereas the combined available capacity of the Eastern and Western 3rd Service Pumps is 15 million gallons daily. The average daily pumpage for both services from the Pimlico Reservoir for this period—June 1 to June 21, inclusive—was 8.8 million gallons, which is an index of the extent to which the insufficiency of water in the Pimlico Reservoir handicapped the operation of the pumping units. (In determining the maximum available capacity noted above—15 million gallons daily—this is based upon the capacity of the new Western 3rd Service Pumps, 10.5 million gallons daily, and the assumption that we use the old Western 3rd Service Pumps to discharge into the Eastern 3rd Service, with a maximum output of 4.5 million gallons daily.) In this connection it should be noted that although we have a maximum of 4.5 million gallons daily available for the Eastern 3rd Service Zone, the lack of a reservoir in this district limits the amount of water that can be pumped during the day and made it practically necessary that the peak demand be met by direct pumpage, as the storage in the standpipe did not last more than thirty to forty-five minutes when the peak came on.

To increase the flow to the Eastern 3rd Service Zone during the maximum draft, a division valve in the Druid or 3rd Service Pumping Station was operated to permit water to flow from the Western 3rd Service; this imposed a heavy draw on the Western Service and to compensate for this as far as possible water was supplied to the Western 3rd Service from an independent source, via (Patapsco River) Avalon, Catonsville Reservoir, 4th Service Zone Standpipe (Ingleside) and Hillsdale Pumping Stations. The flow from this source amounted to approximately 1.14 million gallons daily and it was possible to use it only ten days between June 3 and June 12, as the filter beds at the Avalon Filtration Plant limited their capacity to such an extent as to make it impossible to maintain the water level in the Catonsville 3rd Service Zone Reservoir above the point where the pump suction would be impaired.

The changes in the Distribution System to augment the flow into Pimlico Reservoir, the use of Western 3rd Service to boost part of

the Eastern 3rd Service Zone supply, and the introduction of the Avalon-Catonsville-Hillsdale supply to increase the flow into the Western 3rd Service Zone represented the maximum effort that could be made, with the available facilities, to meet the conditions confronting us, and the service which a large number of consumers were receiving, particularly in part of the Eastern 3rd Service Zone district, was far from satisfactory. Accordingly, it was decided on June 5 to install a temporary pumping station to supply the Eastern 3rd Service Zone from a supply independent of the Ashburton-Pimlico Reservoir System, using a 3 million gallon centrifugal pump which was suitable for the service proposed. This pump was the only equipment we had which could be used, making it necessary for us to obtain a motor and controller, arrange the pump for belt drive, and do all other work required to get the station in operation. Suction was taken from an Eastern 2nd Service Zone 36-inch supply main, the discharge being into a 16-inch Eastern 3rd Service Zone supply main, the two water main connections being within approximately two hundred feet of each other.

The pump was first turned over on June 9, four days after work started, but, due to trouble with the belt drive, was not put into actual service until June 12, one week after the ground was broken. The delivery from this source was at the rate of about 2.90 million gallons daily and the pump was operated daily continuously from early morning until about 11:00 p.m., the deficiency in the service being made up when necessary by operating at Druid Pumping Station.

The operation of the temporary station immediately relieved conditions in the Eastern 3rd Service Zone, and with the removal of the load from the Druid 3rd Service Pumping Station, which the temporary station allowed, a betterment in the Western 3rd Service was soon noticed. By putting into the Western 3rd Service the water which had been going into the Eastern 3rd Service, we were enabled to gradually build up a reserve in Pikesville 3rd Service Zone Reservoir, and at the same time allow the Pimlico Reservoir to return to normal, so that by the latter part of June all districts were being adequately supplied.

During the hot spell the levels in all the reservoirs of the Department were very much lowered, Ashburton or Western 3rd Service Reservoir being drawn down 10 feet, but not enough to cause any uneasiness, with the exception of Towson Reservoir, supplying the

extreme Eastern 3rd Service Zone and for suction of the Pumping Station for Eastern 4th Service Zone. Here the level became so low as to threaten the operation of the automatic pumping station located at the reservoir, and this required us to augment the service by the operation of the Mt. Washington Pumping Station (for emergency use only). By this means, the conditions at Towson were soon restored to normal, and this brought all of our difficulties due to the prolonged hot spell to a close.

During this emergency the engineers and workmen remained on their jobs voluntarily for long hours and without complaint, manifesting only interest in relieving the situation and indeed the excellent coördination of their work was responsible for the success with which the condition was handled.

Our analyses of the condition indicated that it was brought about by the excessive use of lawn sprinklers and hose connections for wetting down the pavements and sidewalks, and the increase in consumption was observed almost entirely in those suburban sections where the water supply services remain unmetered.

Inspectors of the Department were sent into these zones to urge the conservation of water and the Police Department as well coöperated in discouraging waste, for sprinklers were found running twenty-four hours per day unattended. Notices were inserted in the newspapers restricting, by order of the Water Board, the use of hose connections during the mid portion of the day or that portion of the day in which the normal peaks are experienced and finally prohibiting their use altogether until the condition improved.

While it might be said that on the whole the people coöperated, considerable unfavorable comment resulted because of the inability of the people to understand, as was reasonable, why certain sections of the City should experience slack water supply and be subject to restrictions in its use, while other sections of the City remained unrestricted, and while there was 20 billion gallons of water available behind the Gunpowder Impounding Reservoir dam at Loch Raven.

As this belief of the people could not be speedily altered and as Baltimore is practically an unmetered city (16 per cent metered) we met the emergency in the only manner we thought practicable, that is, after trying educational and persuasive methods without success, by providing additional pumping facilities and letting them have all the water they wanted.

DISCUSSION

R. J. Newsom[3]: Last winter in January, the City of Lynn had to meet a situation similar to that described by Mr. Siems; namely, to make a main designed as a distribution main in a certain district, act as a force main carrying a great deal of water and much more than was formerly supposed to go through it.

The city of Peabody, immediately adjacent to the City of Lynn has been using water in excess of the safety sources of supply for some years and gotten away with it until the last two or three years which were very dry. In the fall of 1924 they got down to the point where they had about two months' supply and then the rains fortunately came and they got along for another year. Last fall, however, the drought continued and in January they had reached the place where they had only about one month's supply left and it was necessary to get water immediately from some source.

The only point at which the distribution of the City of Lynn was connected with that of Peabody was in the sparsely settled district of each city, and the main on the Peabody side was only 6 inches so there was no opportunity of getting them any quantity of water. Peabody has not more than 25,000 people, but, due to the presence of several tanneries, they use about three and a half million gallons of water a day. They wanted to get that amount from the City of Lynn.

The pond from which the supply for the City of Peabody is directly taken, is near a thinly settled section of the City of Lynn which was fed by a line of pipe 4000 feet long, 2000 feet of it 10 inches and the other 2000 feet 8 inches.

It was thought that there was a possibility of filling into this pond of theirs from our distribution system, if we could get enough water through that line to be of any assistance. The pressure at the point nearest their pond was only about 32 pounds, the district being very high. And while it was fed by the low pressure system of the city, it was so near the dividing point that there was no possibility of getting any great quantity of water to that main.

At the point where the 4000 feet of pipe began, there were two 10-inch lines coming together. In order to deliver two and one-quarter million gallons of water which we thought we could spare daily, it would be necessary to raise that 40 pounds pressure to 100

[3] Water Commissioner, Lynn, Mass.

pounds. We were anxious to do the work as economically as possible and neither the City of Lynn nor Peabody had a pump of proper capacity. We looked around and found, through the kindness of one of the consulting engineering firms in Boston that there was for sale in the City of Waterville, Me., a pump and motor that exactly fitted the conditions—a pump designed to deliver two and one-half million gallons of water against a 100-foot head.

With less than two months' supply of water in the Peabody system it was necessary to work rapidly and while we did not do the work in a week, we felt that getting the thing in operation in three weeks was fairly rapid.

The pump was shipped from Maine and while it was on its way we made a tapping on each side of the gate which controlled this 4000 feet of main pipe, carried the 28-inch connection over to the side of the street, made a temporary arrangement for the use of some land, dug a pit, concreted it to a depth of 5 feet and had things all ready to set the pump in place when it arrived. The Electric Company in the city fortunately had a 120-foot line in the vicinity and that was sent over. A small wooden structure was built and in about three weeks' time we had the thing in operation.

We found, however, after we got it in operation we had a couple of problems yet to meet which we had not anticipated. In the first place the entire pressure was practically used up in delivering this amount of water to the end of the pipe. Of course, an electrically driven pump has sometimes proved to stop at a rather inconvenient time, due to the interruption in the electric service. When that happened with only 40 pounds pressure at the point where the pump was operating, with an opening 4000 feet away, there was no pressure to deliver water to the houses at the end of that district.

We also found that, even when the pump was operating, there was such an enormous amount of noise in the main due to the rush of water through the 8-inch pipe, and the noise made by the motor at the end of it, that we got serious complaints from the people who were living near that end of the main. By investigating we found that at the point where the 8-inch pipe began, in other words about halfway between the pump and the end of the line, we had approximately 50 pounds pressure when the pump was operating and if the pump shut down we had 20 pounds pressure. To get around both of our troubles, we tapped in a 2-inch line at that point and we

carried it parallel with the 8-inch pipe for a distance of 2000 feet and buried it under the ground. The noise at the point where the 2-inch pipe was tapped off was negligible and of course the pressure of 20 pounds was sufficient to deliver water through a 2-inch pipe for a short length of time until we could get the pump operating without causing any trouble from pulled in water or anything of that kind.

We found, of course, that burying the pipe we wanted to a depth of 6 inches was not going to keep it from freezing in the middle of the night and we realized also that the water was going to be warm during the summer, so we made a small three-quarter connection on the end of the 2-inch line and carried it over into the meter box, put a small meter on that and let that line also run into the pond alongside of the big line. This served to keep the water from freezing in the winter and to keep it cool in the summer.

There were some incidental results from taking on this particular job. It occurred as those things always do, at a time when our own system was drained down. We have pretty good sources of supply and pretty good storage, but while we ordinarily take water into the system in the early fall, it was then the first of February and we were just then beginning to fill. There had not been any water in until that time so it was necessary for us to use water from a source of supply that we put in merely as a reserve in order to fill our reservoir up in the three months that remained. We ordinarily had six months in which to do it. We also found that the taking on of $33\frac{1}{3}$ per cent increase in our load made it impossible for our reserve pump in the pumping station to care properly for the total load and we had only one pumping station. We ordered, therefore, an entirely new set of duplicate parts for the centrifugal pump, duplicating any part of the pump so that we could make a shift in a few hours in case of trouble with that pump.

THE PREVALENCE OF SIMPLE GOITER AND ITS RELATION TO IODIN CONTENT OF WATER AND FOODS[1]

By J. F. McClendon[2]

Iodin was discovered in 1811 and in 1820 was shown to have curative effects on large goiters. Since it did not cause a reduction of the connective tissue and blood vessels in the goiters, complete reduction was not effected from the standpoint of beauty, so its virtues did not become universally known.

Without the knowledge of the element, iodin, iodin-containing substances had been used by the Chinese five thousand years ago and continued to be used in various countries up to the time when it was shown that their virtue lay in the iodin content.

Chatin in 1850–1853 showed that goiter is due to iodin deficiency and advocated the use of iodin as a prophylactic procedure, but did not succeed in convincing the public of this, so it was not until Kimball and Marine, about ten years ago, started experiments on school children of Akron, Ohio, that the prophylactic procedure was adopted. It was immediately taken up by the Swiss and now in some cantons of Switzerland the government sells salt to which iodin has been added, which they call "Vollsalz." In some other cantons they feed school children at intervals with tablets containing iodin. The State of Michigan is now taking up the iodized salt plan. The cities of Rochester, New York and Sault Ste Marie, Mich., are adding sodium iodide to their city water supplies. Tincture of iodin is advocated by Major A. P. Hitchens of the Medical Corps of the United States Army for sterilizing water where safe drinking water is not at hand. The method is to add one drop of tincture of iodin to a quart of water and wait thirty minutes when all the ordinary harmful bacteria are killed. This amount of iodin is too slight to taste, yet ample to protect from goiter, even if such water is drunk only occasionally.

[1] Presented before the Minnesota Section meeting, November, 1924.

[2] From the Laboratory of Physiologic Chemistry, University of Minnesota, Minneapolis, Minn.

It was shown by McClendon and Hathaway that if we draw a line across the United States begining in northern California and passing south of Nevada, Utah and a part of Colorado, bending North to South Dakota, passing south of Iowa, cutting Illinois in two, passing south of Kentucky, and then going northeast parallel to the Atlantic Coast, the region north of this is highly goiterous and the region south of this is almost free from goiter. The region on the north side contains very little iodin in the water and the region south of this line contains much more iodin although still a small quantity. The line of division is of about one part of iodin per billion parts of water, but this is mainly of surface waters because some deep waters and those contaminated with considerable sewage are higher in iodin than the surface waters.

E. F. Eldridge of the Michigan Department of Health has made an iodin survey of Michigan, but his method of analysis was not as delicate as ours and he was not able to detect the iodin in most of the surface waters. He found rather large amounts of iodin in the region of the State in which salt is mined by pumping down water and evaporating the brine. The strip went from Midland near Saginaw Bay to Lake St. Clair. Furthermore the whole southern part of the State contained some underground waters which contained about one part of iodin per billion of water. He did not find any iodin in the northern half of the State where goiter is more prevalent.

Recently, Hathaway has shown that in the State of Utah there is an inverse relation between the iodin in the water and the goiter in the school children; Alpine Canyon and Santaquin show low iodin and a high rate of goiter, whereas Lakeview and Goshen show much more iodin and much lower rate of goiter.

From the iodin balance of the human body, McClendon and Hathaway have shown that about one part of iodin in one hundred million parts of water is perfectly safe to drink exclusively and is about sufficient to prevent goiter even though the diet was extremely goitrous. Some persons drinking goitrous water are protected from goiter by eating foods high in iodin. The article of food, par excellence, for obtaining the iodin ration, is butter. Leafy vegetables and some fruits, particularly tropical or semi-tropical fruits, as well as many sea foods, are also high in iodin.

THE SPACING OF FIRE HYDRANTS[1]

By F. H. King[2]

A water company is interested in the spacing of fire hydrants because hydrant rental is usually one of the principal sources of its revenue. The municipality is interested because upon the spacing depends adequacy of the fire protection and also because of the rating of the town for insurance purposes. Fire underwriters are interested because they know that proper protection means smaller losses from fire and lower rates to the insured. The public generally is interested, but leaves to others the job of looking after the details.

Several years ago Leonard Metcalf, W. C. Hawley and others made exhaustive studies of the investment in water works equipment required to furnish fire protection and the portion of expense of operation due to fire protection requirement and it was shown that the revenue derived from this source was not sufficient to pay interest and expense. Inasmuch as the cost of water works construction has doubled in ten years and the cost of operation has also doubled in the same period, no effort will be made here to show how far short revenue from fire protection now fails to carry its burden of cost; for this revenue, always deficient, has not increased materially, if at all, during the past ten years.

Before the war an average extension would cost say $6600.00 per mile. The same extension today would cost $13,200.00 and ten hydrants at $38.00 per annum each would yield a little under 6 per cent prewar and less than 3 per cent today on the extension alone. The balance of the interest that must be earned on the extension, also interest on feeder mains, meters, supply works and all operating expense and taxes and depreciation must be earned by sale of water to consumers, and it is our experience that in many cases where extensions are ordered there are few or no consumers.

The above shows where the interest of a water company lies in hydrant spacing.

[1] Presented before the Iowa Section meeting, December 4, 1925.

[2] Davenport Water Company, Davenport, Iowa.

Where hydrant spacing is wide the fire department is handicapped because it must carry much more hose to lay the same number of streams on a fire. It takes more time to get the streams in action after the arrival of the department and the effective pressure at the nozzle is much less, due to long lines, consequently the quantity of water available to quench the fire is also less.

All insurance rates are based on the rating of the town, which rating takes into account the hydrant spacing.

Taxes are now so burdensome that no fault can be found with the proposal of the city to set fewer fire hydrants, in order to save hydrant rental, but if the saving is only imaginary and the amount saved is paid in fire losses and extra premiums it would be better to install more hydrants.

The spacing of fire hydrants in Davenport is fairly good and is equal to about ten hydrants per mile of main pipe or one hydrant per 528 feet of pipe. There are 122 miles of pipe and 1211 hydrants. In ten years 36 miles of pipe have been laid and 387 hydrants set which is an average of 10.7 hydrants per mile of pipe laid. The number of hydrants set per mile of pipe has not been less than nine in the past ten years and was 15 in the year 1916, due to the recommendation of the National Board of Fire Underwriters that additional hydrants be located in the principal mercantile district.

Our blocks, are, generally speaking, about 400 feet square. If water mains are laid in one direction only and one hydrant is placed at each street intersection there would be 13.2 hydrants per mile of pipe. If, on the other hand, mains are also laid on all cross streets completing a gridiron, with blocks 400 feet there would be 6.6 hydrants per mile of pipe. Practically the proper number lies about half way between 6.6 and 13.2 so that from ten to twelve hydrants per mile of pipe may well be set in outlying territory.

In their last report on fire protection in Davenport, the National Board stated that in the principal mercantile district the area served per hydrant was 44,000 square feet and in the total area outside the principal mercantile district there was one hydrant to each 190,000 square feet of territory. This report further states that the spacing is good in the principal mercantile district, in most high value districts and in residential districts where the blocks are small; the spacing is wide in some sections where blocks are long or the gridiron incomplete.

The recommendation of the National Board is that there shall be one hydrant at each intersection in residential districts except where

blocks are long and, in such cases, additional hydrants should be placed.

During the past year or two the tendency has been toward wider spacing—in some cases two or three blocks between hydrants—on the score of economy.

Hydrants are operated by men who are not employees of the Fire Department or the Water Department and we sometimes find them broken. One fire that spreads may easily cost more than all the hydrant rental for several years. One hydrant at each street intersection does not seem to be too many and sometimes it is not enough for first class protection.

ZEOLITE SOFTENING PLANT OF THE OHIO VALLEY WATER COMPANY[1]

By F. B. Beech[2]

On November 15, 1922, the Ohio Valley Water Company installed a small zeolite plant to serve a two-fold purpose—first for boiler feed water and second for experimental purposes. This plant paid for itself in the first ten months by fuel saving and boiler maintenance.

After 404 days of constant use the Water Company made careful physical and chemical tests of the material to determine its characteristics as well as its durability. It was found from analyses that there was so little difference between new material and that which had been used in the boiler-house filter for over twenty months, that they might be easily due to sampling. The only important change was an increase in manganese from 0 to 0.28 per cent. This was expected after so long contact with a water containing manganese. It is remarkable that there had been so little accumulation.

Microscopical examination of the used material showed it to be free from coating and to consist of partly rounded brownish grains.

The raw material which is used in the zeolite process is called "Glauconite" by the geologists. The word "Glauconite" is derived from the Greek word "glaukos" meaning bluish gray or greenish gray and the raw glauconite fits this descriptive name very well. The common name for glauconite is "Greensand" and it is this name that the Government bulletins use. At the pits where it is dug it is usually called "marl" or more properly "potash marl."

This material of many names is extensively distributed over the face of the earth but the largest and purest deposits known are in New Jersey. They here form a bed stretching some 100 miles from Sandy Hook on the north to Delaware Bay on the south and are some 10 miles in breadth. Continuing south they cross Delaware, Maryland and Virginia, but the deposits in these other states are not as

[1] Presented before the Central States Section meeting, October 9, 1925.

[2] Superintendent, Ohio Valley Water Company, McKees Rock, Pa.

pure as the New Jersey beds. The thickness of the beds vary from a few feet up to over thirty feet and the supply may popularly be said to be inexhaustible.

These greensand beds crop out at the surface in many places and the amount of overburden that has to be stripped off is usually from four to ten feet and it is not considered very profitable to work beds that are covered with much more overburden than this. The methods, of mining, therefore, are all open pit workings. The overburden is cleared off by scoops or steam shovels and the marl is gotten out by scoops or steam shovel when it is above the water table, and usually by a clam shell bucket when below the water table. The marl when wet is black in color and when dug and dried is grayish green. The clay and fines are what give it its grayish color and when these are washed off the real green color of the material appears. The marl as it accrues is fairly firm and can be walked on in safety but when it has once been stirred up in the water it is as treacherous as quicksand.

The washed glauconite consist of granules of varying size and varying shades of color. The size of these granules runs from less than $\frac{1}{100}$ inch to about $\frac{1}{16}$ inch in diameter. The bulk of the material will pass through a screen running 20 meshes to the inch and will be retained on an 80 mesh screen. The color of the dry grains varies from light green to dark green, sometimes distinctly bluish in tint and the mineral always contains some grains of varying shades of brown. These grains when examined under a magnifying glass appear irregularly rounded and polished as if they had been subject to wave action. Each grain is seen to be made up of smaller particles which are cemented together by a much lighter, almost white material.

Some of the other substances occurring in greensand are limestone, quartz, gypsum and iron pyrites. This last named material is generally called "fool's gold" on account of its golden appearance and the fact that many have been fooled by it. An examination under the microscope will reveal all these substances and will often reveal very small fishes' teeth, many of which are only about $\frac{1}{16}$ inch in length.

The presence of fossils and shell casts points to the fact that glauconite is a marine formation. This has been substantiated by deep sea dredgings made by the "Challenger," by which samples of glauconite in the process of formation on the sea bottom were obtained. In

fact, the shape of many of the particles indicates that they are internal casts of minute shells. The formation of the mineral from iron bearing clays, organic matter and potash, either from the sea water or other minerals is indicated. Glauconite is essentially a hydrous silicate of iron, aluminum and potash but it always contains other substances and analyses of glauconite from different places vary considerably. The following analysis of glauconite taken from Bulletin No. 660 of the United States Geological Survey shows its approximate composition:

	per cent
Silica	50.0
Ferrous oxide	4.0
Ferric oxide	19.0
Alumina	7.5
Magnesia	3.0
Potash	7.5
Water	8.5
Soda and lime	0.5
	100.0

Greensand has also been ground very fine and used as a pigment for making green paint, however, the one use of greensand in which we are most interested is the use of it in water softening, and this depends on a most curious property that this interesting material possesses. This property is called base-exchange, and the substances which possess it are called base-exchange silicates, or popularly zeolites. The name zeolite means "boiling stone" and zeolites are so called because when heated they swell up and give off steam due to chemically combined water being driven off by the heat. When soluble potash salts such as exist in fertilizers are strewn on a field they dissolve in the rain which falls on them and we should suppose that they would be washed out of the ground very readily. Such, however, is not the case. It is found instead that certain substances in the soil combine with the potash and hold on to it so that it is not washed away. These substances are zeolites and the plants are able to obtain their potash from the potash containing zeolites.

Experimental work on these zeolites revealed the secret, and that was that the zeolites were able to exchange bases such as lime, or magnesium, or barium, or soda, or potash, or ammonium, and that these exchanges could be made by simply bringing the zeolite into

contact with a water solution of a salt containing the particular base which we wished the exchange to be made. In time it was found that other substances than zeolites (boiling stones) also possessed these base exchanging powers and among these other substances is greensand. Greensand does not swell up when heated and it is more properly classed among such silicates as talc and serpentine, but since it possesses base exchange properties, it also is called a zeolite.

Raw greensand is most thoroughly washed free from mud and clay, it is then stabilized and finally is screened to proper size. In this refining process about 40 to 60 per cent of material is discarded as unfit for use, these discards being clay, mud and mineral either too fine or coarse.

The term "stabilized" refers to a process as changing a material (clean, sound, greensand) from a softer, fairly easily disintegrated substance to a flint-hard, stable, uniform and not easily disintegrated substance.

When hard water is filtered through zeolite the hardness of the water (the lime and magnesia salts) is removed and the resultant water is termed softened water, soft water or zero water. What has happened is that the zeolite has exchanged its sodium for the lime and magnesia of the hard water. If a soft water, for example, a distilled water, is filtered through zeolite nothing at all happens and no soda is given off. If a water containing 10 grains of hardness per gallon is filtered through zeolite, then the mineral takes out the 10 grains of hardness and puts in an equivalent amount of soda. If water containing 20 grains of hardness per gallon is filtered through zeolite then the mineral takes out the 20 grains of hardness and puts in the equivalent amount of soda, but in this case it will be found that only one-half as many gallons of softened water may be obtained from a certain weight of mineral as of the 10-grain water before mentioned, with the same amount of mineral. In other words, zeolite is insoluble and will give up nothing to a distilled water, but when a hard water comes in contact with it the mineral takes the lime and magnesia out of water and into itself and puts back in the water an equivalent amount of soda. This soda is in the form of the salts of the lime and magnesia originally present. The amount of hardness that a pound of mineral can take out of water is fixed and this figure is called the mineral's "exchange capacity." When this "exchange capacity" or simply "capacity" is "exhausted" the mineral is in its "hard" or lime and magnesia

condition and must be brought back to its original sodium condition before it can soften any more hard water. This restoration is called "reconditioning" or "regeneration." Reconditioning is done by filtering a solution of common salt through the "exhausted" bed. The sodium in the salt solution combined with the zeolite and the chlorine in the salt solution unites with the lime and magnesia of the mineral forming extremely soluble salts which are washed down the drain with the excess of common salt. If the salt wash is tasted, the first portion of it tastes very bitter (like Epsom salts)

TABLE 1

Comparative analyses

DETERMINATION	RAW WATER	EFFLUENT AFTER PASSING ZEOLITE SOFTENER, 1000 GALLONS PASSED
	p.p.m.	*p.p.m.*
Odor, cold, 20°C	1 (aromatic)	1 (aromatic)
Odor, hot, 90°C	1 (aromatic)	1 (aromatic)
Turbidity, silica standard	Trace	Trace
Color platinum	2.0	2.0
Oxygen consumed	2.1	0.9
Nitrogen as free ammonia	0.058	0.098
Nitrogen as total alb. ammonia	0.092	0.016
Nitrogen as nitrites	0.400	0.060
Nitrogen as nitrates	0.360	0.300
Chlorine	15.0	18.0
Alkalinity	68.0	71.0
Hardness by soap method	151.4	0
Iron	0.15	0.10
Total residue on evaporation	490.0	300.0
Manganese	1.3	Trace

due to its lime and magnesia salts, and then gradually this disappears and the taste of common salt (due to the excess of it that is always used) takes its place, this fading out as the pure softened water displaces it.

In the design of a zeolite water softening equipment, the uniformity and size of the grains of the mineral is a factor insofar that if the grains of mineral are too small, there will be an increased loss of head with the water passing through the mineral, whereas the mineral too large in diameter will permit the water to pass without having all the hardness removed, and from experience, the

mineral must be so graded to uniform size as will permit a maximum amount of water to pass entirely softened with the minimum amount of head loss.

The ability to exchange almost instantly is a characteristic of zeolite, particularly so in the softer waters, say up to 16 grains hardness, where the limitations are more of a mechanical nature than the exchange rate of 6 gallons per square foot per minute, now in commercial use.

In such cases where the water hardness is about 20 grains, the exchange rate is about 5 gallons per square foot, per minute and under conditions of a 25 grain hardness, the exchange rate would be 4 gallons per square foot per minute.

From these figures, a 9-foot by 22-foot softener would have the capacity to deliver softened water to zero hardness at a maximum rate of 72,000 gallons per hour or about 1,700,000 gallons per twenty-four-hour period, delivering this amount of softened water under proper conditions of installation.

As to salt efficiency; recent developments in the method of salt application have reduced the $\frac{1}{2}$ pound of salt per 1,000 grains of hardness removed, to a figure slightly over $\frac{1}{3}$ pound of salt or 1000 grains of hardness (as $CaCO_3$)removed.

This development in salt efficiency is principally due to a method of uniformly applying the salt throughout the entire area of the softener as well as to recent developments in the process of stabilization.

Softening by zeolite being comparatively new, the Water Company found that no attempt had been made heretofore to soften water for public use to the extent they required, i.e., 4 m.g.d., so lengthy studies and experiments were made by competent engineers who determined that there was very little difference in costs between softening by Lime-Soda Process and the zeolite process and recommended the installation of the Zeolite Process, consisting of four 9-foot by 22-foot tanks.

SUMMARY AND CONCLUSION

The new plant will remove manganese and Crenothrix, making the water suitable for laundry and other washing purposes, prevent stains on pumbing fixtures and save the large cost which the cleaning of mains and the replacing of services would require.

Lime-soda will reduce hardness from an average of 190 to 60 p.p.m. The Zeolite process may be used to reduce the hardness to any desired degree down to zero.

The Zeolite process requires little space as compared with Lime-Soda process. In fact the Water Company required little or no additional space, having built the softening house on one-half of the existing surface of a covered concrete detention basin (500,000 gallon capacity) which had been used for years.

The Zeolite process is flexible and certain, requiring no highly trained men to operate.

This plant has been in operation for about a month and while it is too early to give any definite operating report, we do know that it fulfills all expectations to date and can be operated cheaper than expected. Salt being the only requirement it naturally follows that the cost of salt is a large factor in cost of operation. The Water Company has secured a yearly contract for salt at 20 per cent less than the original figures.

GROUND WATER RESOURCES OF ILLINOIS[1]

By G. C. Habermeyer[2]

If you cross the river to East Dubuque or go to the City of Galena which is close by and then travel in any direction across the State of Illinois, you will find that the farther you proceed, the poorer are the ground water resources. The principal water-bearing strata in the state are sandstones of the Cambrian system often referred to as Potsdam sandstone. Sandstones of this system outcrop in the central and western part of Wisconsin, north of a line through Milwaukee as far north as Wisconsin Rapids, to the northeast and northwest of that city, and in Iowa and Minnesota along Mississippi River. The St. Peter sandstone, which is above the Cambrian sandstones, is next in importance. The principal outcrop of this sandstone is in southern Wisconsin. It is exposed in Illinois in an area near Oregon on the Rock River, near Ottawa along Fox and Illinois Rivers, and is exposed or close to the surface in a few other small areas. These strata slope downward to the east and south with one sharp fold, the LaSalle anticline, from near the northwest corner of the state southeastward through LaSalle, as given in detail in publications of the State Geological Survey Division.

Possibly the statement that the farther we travel from East Dubuque or Galena the poorer are the ground water resources, is a little broad, for, to the east throughout much of the northern part of the state, considerable water is available in gravel deposits and in the underlying rock strata, especially the sandstones referred to. As far to the east as Rockford, water obtained from Cambrian sandstones is of as good quality as that at Galena and it is available in large quantity. Farther east, in the northeastern part of the state, waters from these sandstones are more highly mineralized and the sandstones are also probably softer than the same strata in other sections. Conditions are probably worst at Des Plaines. Gray Brothers drilled a well there into Cambrian sandstone and, after

[1] Presented before the Iowa Section meeting, December 3, 1925.

[2] Engineer, State Water Survey Division, Urbana, Ill.

placing successive casings of smaller size, abandoned the hole at a depth of 1800 feet. A few years ago the village drilled another well and, after reaching almost as great a depth, gave up the effect to secure any considerable flow from these sandstones.

Near Chicago and south of Chicago, near the eastern border of the state, a considerable amount of water is secured from wells into the upper rock stratum in that locality, the Niagaran limestone. Some of these wells in Cook County have very large yield, but the yield of some of the wells in use is very limited.

Proceeding southeastward, or southeastward and southward from Galena, the change in ground water resources is much more marked than it is to the east of Galena. Until Illinois River is reached, nearly all large supplies are from the St. Peter and Cambrian sandstones. As one proceeds, however, he will find the waters more highly mineralized and the increase in mineral content will be sufficient so that, to many, it will be noticeable to the taste. This is especially true if one travels toward a point far downstream on the river, that is, if he stays in the western part of the state. In the central part of the state west of Illinois River, a few cities pump water from Mississippi River and a few pump water from impounding reservoirs on small streams, but a large majority use the rather highly mineralized waters from the St. Peter and Cambrian sandstones. If Illinois River is crossed at LaSalle or upstream from that point some wells into these sandstones will be found a short distance beyond the river. Along the river a few important supplies have been developed from sandstone which lies between the St. Peter and the Cambrian system.

In the central part of the state, east of Illinois River, the ground water supplies are principally from sand and gravel deposits. Water from underlying rock is in most places too highly mineralized for general use. Where the supply from sand and gravel is not sufficient, surface water supplies are developed.

In the southern part of the state, little water is available from sand and gravel and the waters from underlying strata are highly mineralized. Drinking water is secured in many places from comparatively shallow private wells and several of the larger cities have developed public water supplies using filtered river water. Limited supplies of ground water were developed at Marion, Carbondale, and a few other places, from wells into rock. These rock strata do not extend to the northern part of the state. While the waters are highly

mineralized they are comparatively soft. At some places along Mississippi River, especially between East St. Louis and Alton, at some places along Ohio River, and in a few other limited areas along other streams, considerable water of good quality is available from sand and gravel deposits in stream valleys.

Continuing our travel to the southern limits of the state, as we approach Ohio River we come to wells into sand and gravel and wells into rock which yield considerable water of good quality. The supply is not as abundant as in the northern part of the state and our friend, Mr. Roos, pumps water from Ohio River to supply the City of Cairo.

The sources of the public ground-water supplies in the state are given in detail in Bulletin No. 21 of the State Water Survey Division. A part of the data for a few of these supplies will be given in order to give some definite figures in place of the comparative terms which have been used.

At Galena, near the northwestern corner of the state, the city drilled a well a few years ago. It is 8 inches in diameter below a depth of 150 feet. The top is 610 feet above sea level. St. Peter sandstone is at a depth of 140 feet and the flow from this sandstone at the ground surface was one or two gallons a minute. Cambrian sandstone was reached at a depth of 485 feet. At a depth of 1445 feet the flow was 560 gallons a minute. The well was drilled to a depth of 1513 feet and the flow when the well was completed was 560 gallons a minute. The yields were affected somewhat by yields of other wells, especially one city well 130 feet distant. The water has a mineral content of 260 and a total hardness of 255 parts per million.

At Rockford, in the center of the northern tier of counties of the state, many wells have been drilled into Cambrian sandstones. The elevation of the ground surface at some of these wells is about 100 feet higher than the ground surface at the Galena city wells, the depth to St. Peter and Cambrian sandstones is about 100 feet greater, and the wells are drilled about 100 feet deeper, to about the same depth into the Cambrian sandstone. Wells 12 inches in diameter at the bottom, at considerable distance from other wells have yielded around 1400 gallons a minute. Exact data of the lowering of water level are not available, but it was close to 90 feet. The water had a mineral content of 298 and a hardness of 245 parts per million.

The City of North Chicago on the shore of Lake Michigan, near

the northeastern corner of the state, is supplied with water from two wells. The elevation of the tops of the wells is very near the elevation of the tops of the Galena city wells. St. Peter sandstone was reached at a depth of 820 feet and a record of the wells indicates that the Cambrian sandstone is about as far below the St. Peter sandstone as it is at Galena. One well was drilled to a depth of 2269 feet, which is about the same depth into Cambrian sandstone as is penetrated by the wells referred to at Galena and Rockford. This well, when completed, yielded 1200 gallons a minute. A well 1695 feet deep, 10 inches in diameter at the bottom, is located 65 feet distant, and this accounts for a part, probably a small part, of the yield of 1200 gallons a minute from the deeper well. The well 1650 feet deep yielded 1050 gallons a minute with a lowering of the water level of 100 feet. The wells flow when not pumped. The mineral content of the water from the deeper well is 760 and the hardness 425 parts per million.

The City of Galesburg, in the central part of the area west of Illinois River, drilled a well to a depth of 2414 feet. St. Peter sandstone was entered at a depth of about 1090 feet. The well is 10 inches in diameter at the bottom. It yielded 1200 gallons a minute with a lowering of water level of 46 feet. The water has a mineral content of 1033 and a hardness of 250 parts per million. Waters in use from wells into St. Peter sandstone in this section of the state, contain from 1500 to 3000 parts per million of dissolved mineral matter.

In the central part of the state, east of Illinois River, some waters secured from wells into rock have contained more than 50,000 parts per million of dissolved minerals.

The wells into rock which were used by the City of Marion were about 900 feet deep. Some wells would yield 60 gallons a minute when new, but yields of less than 10 gallons a minute were common. The last sample of water analyzed had a mineral content of 865 and a hardness of 16 parts per million.

A well into rock from which the public water supply of Mound City is secured is 634 feet deep. The top is about 320 feet above sea level. When drilled, the water is reported to have raised to 75 feet above the ground surface and the flow was reported to be 85,000 gallons a day. The water level is now just above the ground surface and water is drawn from the well by suction at a rate of 280 gallons a minute. The water has a mineral content of 280 and a hardness of 135 parts per million.

THE MUNICIPAL WATER AND LIGHT PLANT AT ORLANDO, FLORIDA[1]

By W. W. Mathews[2]

Orlando, Florida, "the city beautiful," determined upon municipal ownership of the Water and Light Plant in 1921. The original plants built in the 80's had become inadequate, and due to the phenomenal growth of Orlando during and subsequent to the World War, the utility situation was very acute about 1920. The following facts will be sufficient to illustrate the burden placed on these utilities.

The population of Orlando increased 137 per cent from 1910 to 1920 and most of this growth occurred in the last three years of that decade. The population has doubled between 1920 and the present time as evidenced by the growth in water and electric consumers as well as local census figures. The present population is approximately 20,000.

This great rate of growth imposed severe financial burdens upon the utility management which could not meet them with the franchise and other conditions then prevailing. Municipal ownership or acquisition of the properties by some company of large financial resources seemed the most practicable procedure. The city and company accordingly agreed upon an arbitration proceeding to determine the value of the properties for transfer.

The company selected Cecil F. Elmes, Chicago representative of Sanderson & Porter, the city selected L. R. Howson of Alvord, Burdick and Howson of Chicago, and Dabney H. Maury of Chicago was chosen as third man. The Board reached a unanimous agreement as to the value of the properties in the latter part of 1921. The citizens by a large majority voted to purchase the properties at the agreed price. The existing plants were taken over and have been operated as municipal properties since 1922.

The City of Orlando was then confronted with the utility problem which it took prompt steps to solve. Realizing the advisability of

[1] Presented before the joint sessions of the Illinois, Iowa and Wisconsin Sections, March 17, 1925.

[2] Assistant Engineer, Alvord, Burdick and Howson, Chicago.

keeping the utilities free from political influence and of having a continuing personnel and policy, the City Commissioners appointed the Orlando Utilities Commission, consisting of five of the city's most successful and influential citizens. The permanence of this Commission was subsequently assured by an Act passed by the State Legislature.

The Utilities Commission selected as its advisors, Alvord, Burdick and Howson of Chicago, who investigated the best means of correcting existing deficiencies, prepared plans and specifications, and supervised the construction of the necessary improvements.

Both the water and light plants required rehabilitation and enlargement. The electric plant could not meet the requirements even with all units in service, voltage was uniformly low, and interruptions in service were frequent. The water supply was taken from lakes. On account of inadequate filter capacity about one-half of the supply was unfiltered.

The determination of the best provision for future requirements was not so simple as in the average city. Orlando up to 1910 had not developed very rapidly. In the period from 1890 to 1910 there was only a slight increase in population, but from 1915 to 1920 the population more than doubled, and the rate of growth was about 20 per cent per year at the time the plants were taken over.

The population of Orlando in 1920 as given in the United States Census was 9282. The number of services connected during 1920 and 1921 indicated that the rate of growth in these years was much more rapid than previously obtained, and that a particularly liberal estimate of future growth was desirable. This was also indicated by the growth of other Florida cities studied, for the entire state had recently been and still is experiencing a remarkable growth. It was estimated that the population of Orlando would be 50,000 by 1950. This is now believed to have been rather too conservative. The improvements built in 1922 and 1923 were designed for 30,000 people.

THE SOURCE OF WATER SUPPLY

Orlando is located in the "Lake region" of Florida, there being 17 lakes of varying size within the city itself. Several lakes were available as sources of supply. Hydrographic surveys were made to determine the storage capacity of the lakes. Rainfall and runoff, and the yield of watersheds were studied from the local and other records. The top soil is all sand in this section. There is no natural

surface runoff, but the rainfall which averages 60 inches per year largely percolates through the sand to the lower impervious strata, thence to the lakes where it is stored in beautiful bodies of clear water of relatively high purity.

Ground water is also available in large quantities and with a static level near the ground surface at Orlando. Comparative studies of first and annual costs of well and filtered lake waters were made to determine which supply would be the most practicable. Analyses of water from existing wells showed that a softer and more desirable water could be obtained by filtering the lake water.

The water in the chain of lakes considered as best of the surface supplies had a hardness of approximately twenty parts per million and forty-one parts per million of incrusting solids. Alkalinity with phenolphthalein was zero, and about ten parts per million with methyl orange. These several lakes afforded storage and had sufficient drainage area to take care of the future needs of Orlando for at least twenty to thirty years. When an additional supply is required Lake Underhill located about two miles east of the city and about 25 feet above the first group of lakes can be utilized by building a conduit through which water would flow by gravity to the first group.

The well waters, while not shown by analysis to have been contaminated at that time, were believed to be potentially unsafe due to the fact that the sewage of the city after being clarified by Imhoff tanks is discharged into wells which "drink" instead of yield. It is believed that heavy drafts for municipal supply would probably result in this sewage contamination reaching the adjacent wells.

It was decided, therefore, after comparing construction and operating costs and the quality and quantity available of both surface and underground waters to use the surface supply and develop first the drainage area of the group consisting of Lakes Highland, Ivanhoe, Concord, Adair and Spring as a source of water supply. These lakes provided a natural storage of 1,300,000,000 gallons.

The preliminary studies demonstrated the impracticability of utilizing any of the old power plant, pumping station, or slow sand filter plant as such. It was recommended that an entirely new plant be built on the shore of Lake Ivanhoe, this plant to contain the power, pumping, and mechanical filter plant all under one roof.

Statistics of the old water and light plant showed that the variation in seasonal loads for both utilities was greater than that ordinarily experienced in the northern cities. In the winter the electric load

was greatly in excess of the average daily load due to the influx of tourists and the operation of the packing houses, citrus fruits being packed almost exclusively during the winter season.

The pumpage naturally increased with the additional number of consumers supplied during the winter. Lawn sprinkling is more general in the winter because of this being the dry season. The soil is sandy, so that a week or two of dry weather is sufficient to cause the average daily pumpage to increase approximately 100 per cent for short periods and conversely a day or two of rain may cause the daily pumpage to decrease 50 per cent compared to the previous day's pumpage. These changes are of course of short duration but occur off and on throughout the year.

The size of the new units to be installed for water service were selected with respect to both the severe peak load conditions, somewhat greater than those experienced further north, and the minimum conditions which occur in the summer rainy season.

For the electric load, the population practically doubles during the winter with a resulting greater seasonal use of electricity than is experienced in this locality.

THE PLANT

Plans and specifications were prepared in the early part of 1922 and bids were received on August 30, 1922. Contractors bidding on the building and coagulating basin would not guarantee a time of completion so the city decided to do this work by day labor under the supervision of the engineers. This was done and the electric plant started to operate on June 1, 1923, and the filter plant on June 26, 1923. The plants have been operating since the above dates.

A station building 172 feet 6 inches long and 98 feet wide, overall dimensions, was required for housing the immediate installations as well as providing reasonable space for future units. This applies directly to space for future boilers and generators for additional filter capacity will be obtained by constructing filters adjacent to the present installation. The west portion of the building houses the boilers and electrical equipment, while the purification plant occupies the east end of the building. The pumping equipment is in the center of the building.

In view of the conspicuous location of the building, situated as it is on a main highway, and also in view of the designer's ideas as to the importance of a building housing the water supply of any community,

more attention was paid to the architectural appearances of the Orlando station than is customary in ordinary water works construction.

The Dixie Highway runs directly past the front of the building, the construction of which made it desirable to re-locate several hundred feet of the highway at this point. Thousands of tourists to south and west Florida pass by the building each year and many stop to inspect it. The building is visible for about $\frac{1}{2}$ mile north and south on the Dixie Highway, and also from across Lake Ivanhoe so that it is the most prominent feature of the landscape, as Orlando is entered by auto from the North. The territory directly adjacent to Lake Ivanhoe enclosed by the highways that encircle the lake, is a city park and the grounds of the water plant are maintained so that they constitute an integral part of the park system.

The design of the building is an adaptation of the old type of architecture which developed during the Spanish era in Florida. The building is constructed mainly of reinforced concrete, but certain upper portions are of brick. The exterior is finished with a white stucco applied directly to the brick and concrete walls.

The roofs over the main building are not visible and are of concrete tile construction on steel trusses and purlins. The lower portions of the building over the filters and entrance lobby are provided with red Spanish tile roofs.

Entrance to the building is by means of a tile paved portal embellished with stone carving and iron railings. Entrance to the generator and pump room is through an attractive lobby whose walls and groined arch ceilings are treated to imitate cut stone. Public toilet rooms finished in marble are located on each side of the lobby. Located in the center of the lobby is a handsomely carved Spanish drinking fountain.

The floors of the lobby, generator and pump room are finished with red quarry tile.

The architectural treatment of the generator and pump room is of extreme simplicity, but carries out the Spanish idea in its general lines and color scheme. The effect of the room upon entering is of extreme light and airiness. The walls are finished in white paint above an olive green wainscoting. While the general color scheme is white the wrought iron work and machinery foundations are painted olive green.

Because the basement contained auxiliaries, low lift pumps and high voltage equipment, it was given particular attention relative to

lighting and ventilation. Windows on the front and south and large pit openings in the main floor provide an abundance of light and air.

In the boiler room in place of the conventional glazed windows large arched openings have been provided and equipped with wrought iron grilles typically Spanish in treatment. These unobstructed openings were not only adopted because of the architectural effect but because they afford an abundance of ventilation for a naturally hot room in a warm climate. They also provide a practical means of moving equipment in or out of the boiler room.

V. A. Matteson of Chicago designed the architectural features of the building.

A brief description of the various units installed in the new plant follows:

Three 512 horsepower water tube boilers constitute the boiler plant. These boilers are equipped with Power Specialty Company superheaters, Vulcan soot blowers and Schuette and Koerting oil burners. A working pressure of 225 pounds per square inch with 100 degrees of superheat is maintained. The Springfield Boiler Company of Springfield, Ill., furnished the boilers.

Owing to the high temperatures which result from the use of oil as a fuel, the combustion chambers of these boilers are somewhat larger than is customary where coal is used.

Some difficulty was experienced in the early operation of the boiler plant. The high temperatures developed with the use of oil caused the front walls of the boilers around the burners to burn out and these walls had to be renewed about every three months. It was discovered that the location of the burners with respect to each other and the inside of the front wall caused this trouble.

There are three burners to each boiler, two of the burners being located at the same height above the floor, symmetrical with respect to the center line of the boiler and the third burner below and centered between the other two burners. The wall opening at each burner is cone shaped with the base of the cone at the inside face of the front wall of the boiler. As first installed there was a wedge between the two top burners 6 inches thick. That this wedge was the weak part of the wall was indicated by failure occurring first at this point.

The difficulty experienced was remedied by moving the two top burners further apart. Another source of trouble was caused by the flame from the burners impinging on the edges of the openings on the inside face of the front wall and which resulted in the wall burning

off at this point. By extending the tip of the burner a few inches forward, this trouble was done away with. Since these changes have been made no further trouble has been experienced with the oil burning equipment.

Oil was adopted as a fuel because the price at which Mexican oils can be obtained in Florida makes this fuel more economical than coal. Oil is pumped to the burners at 175 pounds pressure per square inch after being heated to temperatures of 225° to 250°F. Vaporization is effected by pressure and temperature only, neither steam nor air being inducted into the oil as it is pumped to the burners.

Changes in load conditions are met by changing the tips which consist of a pipe $\frac{3}{4}$ inch in diameter by 24 inches long on the end of which is the tip proper. The tip is made of a high temperature resisting metal and the diameter of the orifices through which the oil passes varies from 0.75 to 2.5 mm. A few seconds is all the time required to change one of the tips and this feature is particularly convenient in meeting the peak loads of the electric plant which come on very quickly.

It is interesting to note the roomy appearance of the boiler room where stokers are not used, and also the cleanliness that is possible with an oil fuel. The boiler room walls were finished in white and after being in use over a year are still white.

The generating equipment consists of two 1500-k.w., 2300-volt A. C. Westinghouse turbo-generators, and one 1000-k.w., 2300-volt A. C. General Electric turbo-generator. The latter unit was moved over from the old plant. C. H. Wheeler surface condensers were erected with the Westinghouse units and the General Electric generator has a Westinghouse jet condenser. Two D. C. exciters were also installed, one being a turbo-generator of 50-k.w. capacity, and the other a motor generator set of 60-k.w. capacity.

Three low lift, three high lift motor driven centrifugal pumps and a small motor driven wash water pump constitute the entire pumping capacity of the water plant. Low lift and high lift pumps have capacities of three million gallons each against heads of 35 and 150 feet respectively. These pumps were furnished by the Morris Machine Works.

In addition to the motor driven pumps three steam pumps with a total capacity of five million gallons daily are maintained in the old pumping station ready for instant use.

Four filters were constructed having a nominal capacity of one

million gallons each when operated at two gallons per square foot per minute. The old slow sand filters were remodeled into two coagulating basins by raising the walls four feet and the installation of baffle walls.

The capacities of the new plant compared to the old plant are as follows:

4000 k.w. to 1780 k.w. in generators
1536 boiler horsepower to 1162 boiler horsepower
14 million gallons to 8 million gallons pump capacity

Comparison of total capacities does not indicate clearly the increased capacities of the new plant. The new boilers can be operated at 250 per cent rating while the old boilers as installed could carry but little overload. Increased efficiencies were obtained in all of the units installed. Higher pressures and efficiencies were developed with the new boilers. It is doubtful if the old water plant could have pumped the rated capacity of eight million gallons per day.

Water is taken from Lake Ivanhoe through a 30-inch cast iron pipe terminating in a 30-inch cross which is located about 350 feet from shore and in 22 feet of water. This intake is connected to a suction well built of reinforced concrete in which are located separate suction pipes for the low lift pumps and the circulating pumps connected to condensers.

The suction well is 14 feet in diameter with the bottom 11 feet below average lake level. The top of the 30-inch intake line is 5 feet below average lake level. Two sets of double screens protect the pump suctions.

Water is pumped by the low lift pumps to 16 aerating nozzles located over the mixing chamber at the rear of the plant. Aeration is provided to remove the odor and taste of algae which is quite prevalent in all of the lakes in this region and to lower the CO_2 content. The mixing chamber which is of the over and under type provides an eighteen-minute mixing period at a 4 million gallon rate.

Dry feed machines installed by the International Filter Company, contractors for the filter equipment, feed the lime and alum. Alum is applied at the first compartment of the mixing chamber and lime is applied after the water has passed through the first coagulating basin.

After passing the aerators and mixing chamber, the water flows through a 24-inch main to the coagulating basins located on the

grounds at the old plant. The slow sand filters were remodeled to provide the two coagulating basins. These basins may be used either in parallel or in series and when cleaning is necessary one basin only is used. The coagulating basins are not covered.

The capacity of the two basins is approximately 1,500,000 gallons affording a nine hour settling period at a four million gallon rate, or approximately eighteen hours during the present average day's use of 2,000,000 gallons. This long settling period is used to effect as high percentage of color removal as possible. This is the main purpose of the coagulating basin at this plant for the turbidity is normally less than 20 parts per million. From the coagulating basins the water flows by gravity to the filter plant.

Four filters having a nominal capacity of one million gallons each when operating at a rate of 125 million gallons per acre per day were installed. Manifolds and perforated laterals are of cast iron. Controllers are of the Venturi type, operating tables are of marble, and are provided with loss of head and rate of flow gauges. All valves are hydraulically operated.

The cast iron laterals are 2 inches in diameter with $\frac{1}{4}$-inch holes spaced 6 inches on centers. Laterals are spaced 6 inches on centers with orifices pointing down. Strainers are used only on a 12-inch cast iron manifold.

Effluent pipes from the controllers turn down into the clear well. Chlorine is applied to the filtered water as it passes through a 5 foot wall opening on the way from the filter effluent, to the pump suctions.

The clear well at the new plant has a capacity of approximately 400,000 gallons with 9 feet of water. It is connected by a 16-inch pipe to the clear well at the old plant which has a capacity of 300,000 gallons. The suction of one of the high lift pumps is connected to this 16-inch line, so that this pump can be used with either the new or old clear well as desired. The other two high lift pumps are connected directly to the new clear well only.

Aeration, coagulation and filtration produce an odorless and tasteless water from which practically all of the color has been removed. Color is usually present in the raw water to the extent of 75 to 90 parts per million, and this is reduced to 10 or 15 parts per million. The alkalinity of the raw water averages about 10 parts per million and the filtered water has an alkalinity of from 35 to 40 parts using methyl orange as an indicator.

Total hardness ranges from 15 to 20 parts per million in the raw

water and from 40 to 45 parts per million in the filtered water. This effluent is much softer than that obtained in most Florida cities, particularly those using an underground supply where the hardness varies from 300 to 1100 parts per million, before being treated to reduce this hardness. One city used water from a group of wells which had a total hardness of 1800 p.p.m.

Two elevated tanks of 250,000 gallons capacity each have been erected. These tanks are located in the southern and eastern parts of the city at some considerable distance from the pumping station, which is in the north central part of Orlando. During times of peak load they feed back toward the center of maximum demand and since installed have caused pressures to be more uniform under varying rates of pumpage.

No particular difficulties were encountered during the construction of the plant. The construction equipment used consisted of one steam concrete mixer with tower hoist, one steam hoisting engine and a tower for hoisting brick and mortar. Two small gasoline mixers were used on certain portions of the work. Labor conditions were ideal. Union labor from all sections of the country was available during the winter under open shop conditions and at a cost of but 65 cents to $1.00 per hour for the building trades.

Five water mains were laid under the tracks of the Atlantic Coast Line and Seaboard Air Line Railways which run past the rear of the plant. These mains range from 16 to 24 inches in size and since the soil consists mostly of sand extra precautions were necessary in this work to protect the trenches against cave-ins with railway traffic being maintained. All mains were placed with the top of the pipe 6 feet below the base of rail.

Installing the intake was an interesting feature of the work. This was accomplished by floating the 30-inch cast iron pipe to the location desired, and there sinking it.

The method followed was to first build a launching platform about 100 feet long and 6 feet wide of two inch lumber. This platform extended out into the lake about 50 feet at the start of the work. A 12-foot by 12-foot platform of large timbers and planking was then constructed on the launching platform on shore. This heavy platform was supported on rollers and was to serve later as a support on the lake bottom for the cross at the outer end of the intake line.

The 30-inch cross was then placed on the 12-foot by 12-foot platform, anchored by means of two sets of ½-inch round stay rods passing

over the cross and through the platform. The purpose of this support under the cross was to prevent it sinking into the soft material on the bottom of the lake.

Wooden bulkheads were caulked into three openings of the cross, oakum only being employed to insure water-tight joints. Steel cables with floats were attached to each bulkhead, so that they could be pulled after the pipe had been placed in its final location.

With the cross in position on the platform, pipe was added one length at a time also on rollers until several joints had been connected up and all available space on the launching platform had been utilized.

That part of the intake connected up was moved far enough forward on the launching platform to permit further connections to be made. Two sets of block and tackle were used to prevent the pipe getting out of control and sliding out into the lake.

Computations showed that the weight of Class "A" 30-inch pipe required additional buoyancy to prevent its sinking prematurely in the event of any material amount of leakage occurring at the bulkheads. Water-tight barrels were used for pontoons, two being utilized for about two lengths of pipe.

After a part of the intake line was floating the process was simple, care being taken, however, to prevent the line from sliding out into the lake. The shore end was naturally higher than the floating section and the pipe moved very easily, in fact almost too easily after several lengths of pipe were floating.

The bulkheads leaked slightly and water was pumped out of the intake line by a trench pump having wrought iron pipe connected to the suction. Additional lengths of wrought iron pipe were added as the intake increased in length.

After the intake line had reached a length sufficient to bring the cross over a predetermined point, pumping was stopped and the line allowed to fill. The time required to sink this line was approximately one and one-half hours.

Sinking the intake line left the shore end several feet above the final elevation of this end of the line. It was in line, however, with a 30-inch stub already connected to the suction well on which was located a 30-inch valve.

A suction dredge was employed to remove the sand under the pipe until it was at the proper elevation, after which the dredge was reversed and sand pumped back covering the pipe. A bulkhead pre-

vented the sand from filling in the section where final connection was to be made. An ordinary sleeve connection was used to connect the two sections of the intake line.

It was expected that a winch on the dredge would be utilized to pull the bulkheads. When this was attempted, however, it was found that the bulkheads had swelled to such an extent that the winch could not develop sufficient power to pull them from the cross, and it was necessary to use a diver to cut them out. A diving outfit was procured and one of the water works employees who has had previous experience as a diver cut out the three bulkheads in about one day. He also removed the barrels which had sunk with the intake line.

This work was completed without an accident and cost less per foot than laying 30-inch pipe under ordinary conditions in a trench. The intake line was installed by E. M. Austin, Water Works Superintendent for the Orlando Utilities Commission.

An examination of the distribution system showed that the pipes were very badly incrusted, and in some cases 4- and 6-inch pipes had openings so small that it was barely possible to pass sewer rods through them. Numerous tests of the distribution system showed that the average carrying capacity of the pipe tested was 30 per cent of that of pipe the same age, based upon Weston's Friction Tables. Some cleaning had been done before, but a general cleaning of the whole system had never been attempted. It was decided at this time to clean all of the pipe 4-inch in diameter and above, except one 16-inch which had been laid only a short time before.

This work was done by the National Water Main Cleaning Company. Approximately 20 miles of mains were cleaned, ranging in size from 4 to 12 inches. The cleaning increased the capacity of the system approximately 50 per cent with a resulting increase in pressure throughout the city. The cost of the work averaged 10.33 cents per foot, 8 cents of this being the contract price to the Cleaning Company and 2.33 cents the cost of labor supplied by the city.

The pressure maintained by the old company in the center of the city except at times of fire was 25 pounds per square inch. This was increased to 35 pounds per square inch when the city took over the old plants and since the new plants have been operated, the pressure maintained varies from 60 to 65 pounds per square inch. The city is comparatively level and pumping engines are used for fire fighting, so it was felt that a higher pressure would not be justified.

Besides raising the quality of service provided heretofore, the new

plant has proved very economical in operation which was forecasted when estimates of cost of construction and operation were prepared. The greatest economy which resulted from the installation of the new boilers and generators has been in the oil consumed. The saving in oil alone is sufficient to pay approximately 10 per cent interest on the investment in the new plant which more than justifies the expenditures made.

A very small operating force is required, one operator, one oiler and one fireman constituting the operating force on each eight hour shift for the electric plant, filter plant and pumping operations. The operator is in charge of the plant during his shift and is responsible for the continuity of service both of the electric and filtration plants. He is assisted by the oiler who washes the filters, watches the dry feed machines, and keeps the hoppers filled with coagulant. With oil burning equipment one fireman only is required on a shift. The plant as a whole is in charge of the Chief Engineer with mechanics, boiler washers and laborers as needed.

The layout of both the water and electric plants is such that additions may be made as future demands arise without losing any of the first investment. Additional filters may be built adjacent to the present filters on the east and the pipe gallery and piping extended. Pipe now installed in the pipe gallery is adequate for a filter plant of more than double the capacity of the present plant. Space is also available for additional coagulating basins.

In the generator room space has been provided for one additional generator which when installed will be larger than any of the present generators. When still further capacity is required the present No. 1 unit or 1000-k.w. turbo-generator may be replaced or the building extended, the program to be followed at that time depending upon the more economical of the two procedures.

In the boiler room, space is available for another boiler. At the present time one boiler out of three is sufficient to carry the load except at peaks during the winter months when a second boiler is used to help out for a short time. Additions to the boiler plant will follow in a general way increased generating capacity.

The water and light plant functions under the administration of a Board constituted by act of legislature, and is entitled the Orlando Utilities Commission. This Board consists of five members, each of whom serves for six years and without remuneration. The Board elects one of its own members President. The first Orlando Utilities

Commission was appointed by the Mayor and consisted of the Presidents of the four banks and the President of the Building and Loan Association. The success of the Municipal Water and Light Plant at Orlando is due in no small measure to the efforts of this first Commission who assisted very materially in financing the plant to its completion.

The construction of the plant and the installation of equipment were under the supervision of the writer who represented the Consulting Engineers on this work.

DISCUSSION

L. I. BIRDSALL: What were the pressures before and after main cleaning?

W. W. MATHEWS:[2] This work was completed before the new plant started to operate. It was necessary to maintain about 90 pounds pressure at the station to insure 35 pounds at the office downtown. After cleaning 60 to 65 pounds at the station would give 35 pounds pressure at the downtown office.

L. I. BIRDSALL: What was the depth of water at the outer end of the intake line?

W. W. MATHEWS: The cross at the end of the intake line was located in 22 feet of water. It was expected that the depth of water at this point would be ten feet but dredging for the new location of the Dixie Highway increased the depth of water very materially on the side of Lake Ivanhoe where the new plant is located.

L. I. BIRDSALL: What is the temperature of the water?

W. W. MATHEWS: The average temperature is about 80°F. or a little above. For a very few days in the winter it gets below 70°F.

L. R. HOWSON: There is no choice between the temperature of water from wells or from the surface supplies. The temperature of the well water is 74°F.

IMPROVEMENT OF SETTLING BASINS[1]

By W. H. Kimball[2]

In 1901 the Davenport Water Company constructed at its main pumping station on the Mississippi River a concrete sedimentation basin with a capacity of 3,700,000 gallons. This basin is somewhat irregular in shape, this being necessary to accommodate it to the available land. Its total length is about 470 feet, its width at the west end 128 feet, and at the east end 67 feet. The average depth of water in the basin is about 12 feet.

This basin as built had no division walls or baffles and has been in continuous use since it was built. The water from the river is pumped through a 24-inch cast iron pipe which discharges near the east end of the basin. The sulphate of alumina used as a coagulant, enters this 24-inch pipe beyond the west end of the basin, and the water from the sedimentation basin passes from it to a battery of 12 pressure filters, located in the filter building to the west. The plant has always been carefully operated, and water of an excellent quality has always been furnished, although within a few years after the sedimentation basin was put into operation it was realized that better results could be obtained from it if it were divided into two or more compartments, and plans for such a division were prepared prior to the War. Finally, late in 1922, a plan for a wall dividing the basin transversely into two approximately equal compartments was approved, and in March, 1923, a contract was made for this construction.

The division wall was built in September, 1923.

A section of the wall shows that it forms a deep narrow trough, the water from the east part of the basin flowing into this trough over the top of the concrete wall which forms a weir.

After entering the trough the water flows downward, along the whole length of the wall, to an opening controlled by a 30-inch gate valve at the center of the wall and near the bottom. In an emergency

[1] Presented before the Iowa Section meeting, November 6, 1924.

[2] Consulting Engineer, Davenport, Iowa.

it is possible by opening another 30-inch valve to pass the water directly from basin 1 to basin 2.

The hollow space within the division wall may be provided with baffle planks to still further regulate the flow to the gate valve, although these baffles have not been installed.

It will be apparent that drawing the water from the east basin over a shallow weir practically the full width of the basin, creates a slow, even and undisturbing flow, so that sedimentation in the east basin is very complete.

The water enters the West basin or No. 2, in a clear condition, and flows from No. 2 into No. 3, which is a small semi-circular basin,

TABLE 1

Quantity of sulphate of alumina used, in grains per gallon, monthly averages, for the twelve months immediately preceding construction of cross wall (1), for the twelve months immediately succeeding construction (2) and the average for the fourteen years ended January 1, 1924 (3)

MONTH	1	2	3
October	2.56	2.74	3.33
November	2.19	1.59	2.72
December	2.24	1.49	2.30
January	2.21	1.24	2.23
February	2.56	1.68	2.80
March	3.07	2.57	3.72
April	3.51	2.68	3.15
May	2.82	3.25	3.45
June	4.08	4.17	4.23
July	5.40	4.02	4.09
August	4.34	4.13	4.05
September	4.07	3.11	3.69

where it is given a final dose of sulphate of alumina before going to the filters.

At all times a dose of chlorine is also given the water in basin No. 3.

After the construction of the division wall in September, 1923, a summary of the new plan of operation was prepared by the Davenport Water Company (see table 1).

The cross wall was completed and basin put in service September 28, 1923.

The turbidity of the raw water for the twelve months after the wall was constructed was generally higher than during the twelve months

preceding, especially in the months of June, July and August. The average turbidity of the water treated with alum recorded in column 1 in June, July and August was 187, 211 and 113 respectively while in the same months in 1924 the average turbidity was 326, 382 and 450 (column 2) showing that less alum was used to treat water having much higher turbidity. The maximum turbidity in August, 1923, was 275 (column 1) the maximum turbidity in August, 1924, was 900 (column 2).

In August, 1923, the average number of colonies counted on agar at 37 degrees was 19,600 for raw water and 14 for filtered water. In August, 1924, the corresponding figures were 13,400 and 16.

It should, however, be stated that the quantity of sulphate of alumina used here is not governed directly or entirely by the turbidity. Other factors such as algae and bacterial pollution sometimes control in determining the proper dose of chemicals.

During the winter of 1924 plans for additional improvements to the settling basin were prepared, and these plans were carried out in September and October, 1924.

These improvements included a mixing chamber, a chemical storage house adjoining the division wall in basin 2 and a baffle frame and baffles extending entirely across the west end of basin 2, together with a valve box or chamber into which the water enters after passing the baffles.

The mixing chamber is of reinforced concrete, 12 feet wide, 30 feet long and 12 feet deep. It is provided with brick baffle walls about 30 inches apart extending to just above the water surface. These baffles aid in efficient mixing of the chemicals with the incoming water from basin 1.

The mixing chamber is covered with a reinforced concrete slab, and is entirely enclosed on top by a brick superstructure.

The baffle frame at the west end of basin 2 is of reinforced concrete with $1\frac{1}{2}$-inch by 6-inch cypress baffle planks. Its purpose is to prevent direct flow through basin 2 to the outlet, the baffle openings being so proportioned that the flow takes place along the entire length of the baffle.

The valve chamber was a necessary adjunct to permit and control the flow back of the baffle into basin 3. It is built of reinforced concrete and provided with two 24-inch gate valves and operating stands.

The designs of the reinforced concrete work were all quite simple

and present no unusual features. There was no attempt made to build the lightest sections possible. On the contrary, the work is all substantial.

All of the cement used in the work was tested at the University of Iowa; sand, gravel and stone were carefully selected, and in part of the work, such as the division wall, were carefully graded.

Proportions were 1:1½:3 for the division wall, and 1:2:4 for the rest of the work. All of the work is water-tight, and all submerged steel is protected by at least 3-inches of concrete. No waterproofing compounds were used nor required with the carefully graded mixtures employed.

The Priester Construction Company of Davenport were the contractors for all of the work and deserve credit for the rapidity and throughness with which it was done.

The plans were largely due to local conditions and followed the design of the basin which was piped for an expected division at the time of original construction. Observations and experience of the operators were also considered in the final arrangement.

The engineering features of the work, the designs, the preparation of the plans, specifications and contract, and the carrying out of the construction were under the personal supervision of Wm. H. Kimball, Consulting Engineer.

SAMPLING OF FILTER SAND

By W. S. Mahlie[1]

We have always had a little curiosity regarding the sampling of filter sand, especially as to whether the samples ordinarily taken represent with fair accuracy the composition of the entire lot of sand. A good opportunity presented itself recently during the construction of some additional filter beds, to check up on this special problem.

The sand generally used for filter plants in this part of Texas, is obtained from Goliad, Goliad County, Texas, and is known as Goliad Sand. Numerous tests made at different times have indicated this sand to be about 0.29 to 0.31 mm. effective size, and about 2.15 uniformity coefficient. Inasmuch as this sand apparently was a little too fine, it was decided to place the sand in the filter beds, wash it and then scrape it until the proper size was reached. Accordingly the sand was treated in this manner. The results obtained are shown on table 1.

Regarding the methods of sampling, the samples marked "grab sample" were taken by simply picking up a small portion here and there, after the sand had been placed in the filter beds, but before washing. The samples marked "core sample after first washing" were taken as follows: After the sand had been washed, the filter waste valve was opened and the excess water allowed to drain out. A piece of 2-inch copper pipe about 4 feet long was then pushed down into the sand for a distance of 6 or 8 inches and then carefully withdrawn. The wet sand packed itself in the tube nicely and was then dislodged easily by striking the tube lightly on the side. The process was repeated until the core was cut through to the gravel layer.

The samples marked "6 inches below surface" were taken at a point 6 inches below the surface of the sand bed, and represent the sand at the 6-inch depth, but do not represent the top 6 inches of sand.

The same is true for the samples marked "12- to 15-inch depth" This depth represents the point half-way between top and bottom of the sand bed.

[1] Chemist in Charge, Filtration Plant, Fort Worth, Texas.

The final samples after washing and scraping represent the sand as finally accepted. In all, about 4 inches of sand were scraped from the top of each filter bed.

This test brings out the following facts:

1. The grab samples and the core samples are in fairly close agreement.

2. A hydraulic grading takes place during washing.

3. Samples taken at certain predetermined depths are affected by

TABLE 1

Filter sand tests

FILTER NUMBER	GRAB SAMPLE		CORE SAMPLE		6 INCHES BELOW SURFACE		12 TO 15 INCHES BELOW SURFACE		FINAL SAMPLE	
	E. S.	U. C.	E. S.	U. C.	E. S.	U. C.	E. S.	U. C.	E. S.	U. C.
9	0.30	2.07	0.29	2.02	0.32	1.28	0.48	1.52	0.37	1.78
10	0.30	2.10	0.31	2.03	0.32	1.68	0.33	1.88	0.38	1.92
11	0.31	2.10	0.33	1.85	0.32	1.56	0.35	1.77	0.36	1.92
12	0.33	2.15	0.30	2.19	0.35	1.26	0.48	1.60	0.39	2.00
13	0.31	2.00	0.32	1.88	0.33	1.24	0.41	1.29	0.36	1.72
14	0.34	2.18	0.33	1.97	0.35	1.32	0.44	1.55	0.36	1.86
15	0.31	2.03	0.30	2.00	0.32	1.28	0.44	1.39	0.37	1.89
16	0.31	2.10	0.32	2.19	0.33	1.33	0.43	1.56	0.39	1.82
Average..	0.31	2.09	0.31	2.02	0.33	1.37	0.42	1.57	0.37	1.86

the depth at which they are taken, and approach unity as a uniformity coefficient.

4. A midway point is not a representative sample, nor is the top 6-inch sample a representative sample of the entire bed.

The conclusions we draw from this little experiment indicate to us the need for something to take the place of our present effective size and uniformity coefficient methods of judging filter sands used for rapid sand filters.

FINANCING WATER MAIN INSTALLATIONS[1]

By D. A. Reed[2]

The term "financing of water main installations," it is taken, means not merely the job of procuring the money and paying for the extension, but the method of assessing or fixing the cost of these extensions upon the proper parties, either by some process of assessment where the plant is municipally owned, or by the use of guarantees or other arrangements in the case of the privately owned plant. Much confusion seems to exist and there are almost as many different methods of handling these matters in both municipal and privately owned plants as there are plants.

Frank C. Jordan, Secretary of the Indianapolis Water Company, has procured some valuable data on this subject which are printed in the September, 1924, number of The Journal. This report shows many typical illustrations of the methods used.

In one case the property owner pays the cost of the mains in full in front of his property. This seems to be inconsistent with good business practice for several reasons. First, the customer of any business or of a utility is not supposed to pay direct capital investment and in addition pay earnings upon the same investment. In fact, a business of any kind should be conducted upon the basis of ownership of all of the plant necessary to conduct the business, and the customer should not be assessed for capital investment except such share of the rates charged for the commodity furnished as a customer pays when he meets his current bills. As it is impossible to pay for the entire plant by this method and, owing to changing methods, even to pay for all the extensions, it would seem evident that one customer or class of customers would be assessed where the remaining customers would not be. Consequently, this method would be unfair. Also where property is assessed a certain amount per front foot, for instance as at Washington, D. C., or Reading, Pa., or where

[1] Presented before the Minnesota Section meeting, November 14, 1924.

[2] Manager, Water and Light Department, Duluth, Minn.

any amount is assessed as a part of the capital investment and where this amount approximates the cost of the main, it results in making the property owner pay for the main and also earnings upon the same investment. We might go through the whole list of cities quoted by Jordan and find some injustice in connection with the methods used. There is one method, however, used at New Britain, Conn., where they have an assessment of 10 per cent of the cost of the main assessed against the abutting property for ten years. If this 10 per cent is a proper charge for the capital investment necessary to make the extension it would seem to be a method of some merit. However, there seem to be no credits provided for upon this assessment for the overhead charges which are met by a portion of the water rates, consequently the customer is paying for this item something more than what would be just if he is a customer and paying the regular rates for water furnished.

Before formulating a method which would be ideal it would seem necessary to establish certain principles. As a tentative guide the following are suggested:

1. Whether the utility is privately or municipally owned it should be organized with its own and separate fund independent of all other funds, especially the municipal plant with its entire revenue derived only from the sale of water and such service as it may render, with free service to none and a charge to all based upon the cost of service rendered.

2. The rates should be sufficient to cover all operating expenses and fixed charges including depreciation, and in addition a sufficient margin to retire its indebtedness within a reasonable time. As a municipally owned plant or as a privately owned plant it should furnish a fair earning upon the capital invested.

3. Both plants, whether municipally or privately owned, should have a working surplus of available cash sufficient to meet the cost of ordinary extensions without borrowing or bonding the plant. Exceptions might be made to this where a city is growing too rapidly or where extraordinary large extensions are made in one year. This would answer the question as to financing, strictly speaking, of water main extensions.

4. The cost of extensions should be borne only by the parties served and should not be a burden or a tax upon the original plant.

5. If overhead and operating expenses are forthcoming from its

customers immediately upon the installation of the extension, all difficulties cease and there is no problem to solve.

In the making of extensions, however, it is seldom that all of the above conditions prevail. The most troublesome one is that there are not sufficient customers to furnish revenues sufficient to meet all of the expenses enumerated in clause 2 above. In examining the incomes derived usually from new extensions we find that the *operating expenses* in the sale of water to the individual customer is sufficiently met by the rates paid by the customers in almost every instance. However, when it comes to the matter of the *overhead expense* or *fixed charges* on a capital investment it is entirely different. One extension with no customers would pay none of this expense. With a few customers they would be able to pay a portion of that expense as represented by that factor of the rates paid which represents overhead expense. If there were sufficient customers and enough business upon the extension to meet all expenses, both overhead and operating, no assessment or guarantees of any kind would be necessary. Consequently, if it cannot be determined in advance how profitable an extension may become after it is installed, it would seem necessary to adopt some means of assessment in the municipal plant by which the deficiency in revenues could be met by those that are interested in the extension or are benefited by its installation. It is suggested as being practicable that, at the end of the year after an installation is completed, that portion of the rates paid the utility for water furnished by this extension which goes ordinarily to meet overhead expenses and fixed charges be separated from the balance of the rates which go merely to meet operating expenses (such for instance as the pumping of water, the reading of meters, the making out of bills, collecting monies, etc.). This may amount to four or five per cent on the capital investment and generally runs from one-third to one-half of the rates charged for water where rates cover all expenses.

This should be applied upon the fixed charges of the extension and the balance assessed against the abutting property served or benefited. This would seem to meet every requirement and is what the writer believes should be adopted for the solution of this problem.

In connection with this method I wish to explain what has been done in Duluth and perhaps the better way would be to read this Ordinance:

ORDINANCE NO. 489

By Commissioner Merritt:

AN ORDINANCE PROVIDING FOR THE EXTENSION OF WATER AND GAS MAINS IN THE STREETS AND OTHER PUBLIC WAYS OF THE CITY OF DULUTH, AND PROVIDING FOR THE ASSESSMENT OF PART OF THE COST THEREOF AGAINST THE PROPERTY BENEFITED THEREBY

The city of Duluth does ordain:

Section 1. Whenever the council shall order the extension of water and gas mains, upon a petition, as provided by section 62 of the charter of the city of Duluth, and upon the completion of said extension and appurtenances, or any part thereof, an assessment shall be made against the property specially benefited by such extension or portion thereof so completed, which assessment shall be payable annually, for a period not exceeding fifteen (15) years, and for each year shall be eight per cent (8 per cent) of the total cost of said extension, including engineering and other expenses, or so much thereof as may be completed.

Provided, however, that said assessment may be reduced or discharged in the manner hereinafter provided.

Provided further, That in determining the cost of any extension assessed under the provisions of this ordinance, any cost, arising from the laying of mains larger than six (6) inch mains for water and four (4) inch mains for gas, over and above what would be the cost of such six-inch and four-inch mains respectively, shall not be included.

Section 2. An extension shall be deemed completed when either water or gas is turned on in such extension.

Section 3. Said assessments for extensions shall in all cases be made against the property specially benefited thereby.

Section 4. Assessments made under this ordinance shall be made by the registrar of the water and light department, who shall make an assessment roll containing in columns the name of the owner of each lot or parcel of land separately assessed, if known to him, a description of each lot or parcel of land, and the amount assessed separately against each lot or parcel of land; and the assessment roll shall be so kept as to show the continuing nature of it for a period of fifteen (15) years, and all payments or credits made or to be given; and said assessments may be, if necessary, revised from year to year.

Section 5. The engineer of the water and light department shall make and forward to the registrar a plat and survey of the proposed extension and the property to be assessed, which plat shall be attached to the assessment roll; and the said engineer of the water and light department shall, before the registrar makes the assessment, furnish to the registrar a certified statement of the cost of the improvement and the engineering and other expenses in connection with said improvement.

Section 6. The registrar shall certify an assessment roll to the council, and thereafter the city clerk shall give ten (10) days' notice, by one publication in the official paper of the city, that the assessment roll is on file in the clerk's

office, which notice shall describe the extension and shall state a time at which the council will meet to hear the appeals of parties aggrieved to such assessment.

Section 7. At said time the council shall meet and hear and determine upon all objections which may be made by any party interested, to the regularity of the proceedings or to the correctness of the amount of such assessment, or of the amount levied upon any particular lot or parcel of land; and if the proceedings are found to have been regular, they shall correct any errors which may be found in the assessment, and shall thereupon, by resolution, approve and confirm such proceedings; and the proceedings and assessments, as so confirmed, shall thereafter be deemed the final determination of the regularity, validity and correctness of the assessment and the amount thereof.

Section 8. After the completion of said extension, whenever any water or gas is served to any property upon said extension, credit shall be given upon the assessment against the property so served, amounting to one-half of the total receipts for water, and one-third of the total receipts for gas, for each year;

Provided, that the council may at any time previous to Jan. 1 of each year change the proportion of water and gas receipts which may be applied in credit upon the assessments.

Section 9. Such assessment shall be deemed entirely discharged, together with the lien thereof, whenever one-half of the total gross receipts from the sale of water, and one-third of the total gross receipts from the sale of gas in said extension, shall equal or exceed for one year the total amount of such assessment.

Section 10. Assessments, or the unpaid portion thereof, may be paid in full in one payment by any property owner, by paying the balance due thereon, less 25 per cent of said balance.

Section 11. On or before the first day of October of each year, the registrar shall certify to the city council a statement of all assessments delinquent under this ordinance, describing the land affected, and giving the amount of the assessment, with penalty added, after which the assessment shall follow the provisions of section 70 of the city charter.

Section 12. So far as relates to assessments for the improvements described in this ordinance, this ordinance shall be deemed to supercede all prior ordinances.

Section 13. This ordinance shall take effect and be in force thirty days after its passage and publication.

Passed June 8, 1914.
Approved June 10, 1914.

W. I. Price, Mayor.

Attest:
C. S. Palmer, City Clerk.

By a study of this ordinance it will be noted that only deficiency revenues are assessed against the abutting property, that is, such shortages as are not available in the rates paid for water by the regular

customers, and only until there are sufficient customers on the extension so that the overhead factor in these rates meets the overhead expense of the investment in the extension. Then all assessments cease. The City has just completed near Morgan Park an extension costing over $18,000.00 in which the 8 per cent assessment is over $1440.00. There is not a single house upon this extension and all of this $1440.00 is, under this plan, due and payable to the Department within forty days from the completion of the work and the same

TABLE 1

Statement of assessments, Duluth, Minn.

December 31, 1923

YEAR COMPLETED	ORIGINAL ASSESSMENTS		ASSESSMENTS DISCONTINUED UP TO DECEMBER 31, 1923		ASSESSMENTS IN FORCE DECEMBER 31, 1923		NET AMOUNTS LESS CREDITS FOR USES DECEMBER 31, 1923	
	Number of assessments	Amount	Number of assessments	Amount	Number of assessments	Amount	Number of assessments	Amount
1914	17	$1,498.32	11	$1,085.04	6	$413.28	6	$219.66
1915	59	5,763.44	34	2,678.85	25	3,084.49	25	1,688.01
1916	66	7,821.47	31	2,716.05	35	5,105.42	35	2,389.24
1917	48	8,496.98	12	2,395.73	36	6,101.25	36	3,618.25
1918	9	1,729.62	3	350.78	6	1,378.84	6	1,001.00
1919	19	5,629.12			19	5,629.12	19	4,234.32
1920	39	9,179.57	3	174.46	36	9,005.11	36	7,047.11
1921	31	12,034.72	2	78.85	29	11,955.87	29	8,826.56
1922	39	6,999.56	1	28.72	38	6,970.84	38	5,748.26
1923	55	9,732.30	1*	88.84	54	9,643.46	54	9,338.20
	382	$68,885.10	98	$9,597.42	284	$59,287.68	284	$44,110.61

* K 49 cancelled.

amount is paid each year for a period of fifteen years provided there are no customers. This would amount in the total to $21,600.00. In other words, $21,600.00 is what the Department would receive as payments for an investment of $18,000.00 for fifteen years, in case no customers were over obtained that were tributary to the extension.

In comparison with this we will suppose that the extension was made into a thickly settled district or one that built up very rapidly the first year so that the total annual revenues from this extension amounted to not less than $2880.00. If it had been decided that the

overhead expense of the entire plant was one-half the total of the whole expense, including operation, $1440.00 would be credited on this assessment which would cancel the assessment the second year. Of course, it would not be possible to cancel the first assessment immediately on the completion of the extension for the reason that there would be no customers and no credits the year previous to the completion of the extension. It is not possible to go into all of the details of the plan which has been worked out. However, the above seems to be sufficient to give a comprehensive idea of how the plan works and what its advantages are. This plan was first installed in June 1914 and has now been in operation for over ten years. Table 1 is a résumé of its operations during that time.

It is believed that a State law might be passed which would authorize cities generally to make assessments in accordance with the above plan or authorize cities to assess deficiency revenues. It is, however, thought that the plan would be just as desirable for private corporations as for a municipal plant, and perhaps also for street railways and gas plants and certain other utilities.

The plant at Duluth, of course, includes both water and gas and the assessments are combined and made in one. The difference between the water and gas is that credits from gas receipts are one-third, whereas the water receipts are one-half the rates or revenues.

It will be observed that the ordinance can be amended at any time to permit necessary changes in the percentage rate of assessment or to change the fraction representing credits in order to fit existing or changing conditions.

The citizens generally are well pleased with the plan. The assessments are light, running from $2.00 to $10.00 per lot where there is no rock (this also includes gas mains), and with credits for consumers who eliminate the assessment in almost every case. In the 382 extensions made in the past ten years, there has been but one appeal, the court deciding that the assessment should be made by frontage instead of by area. Since then the ordinance has been changed so that assessments can be made either by frontage or area methods. There are many interesting features in connection with this method that it would be profitable to discuss, but enough has been submitted, it is believed, to start discussion.

NIGHT PUMPAGE RATES[1]

Topical Discussion

E. J. Jenkins:[2] The East Chicago Plant, which I will use for the basis of my discussion, is 100 per cent metered. I find on checking the meter records of this plant for the year 1924, that 18 per cent of the total water pumped is pumped between 12 midnight and 6:00 a.m.

We have in East Chicago 61 large industries, who use 58 per cent of the total water pumped. These plants run twenty-four hours, and I think it fair to assume that the water pumped in these hours is used by these consumers.

In 1924 the per capita pumped was 138 gallons, of which the industries used 58 per cent, or 80 gallons, leaving domestic per capita, 58 gallons.

In taking a pumping station meter chart at random, I find that the minimum rate on a normal day is approximately 150,000 gallons per hour. This figured against the population gives 80 gallons per person per day, which is an exact check of the average per capita demand that our actual metered sales show went to the industries.

In other words, I am satisfied that our night load is practically all accounted for by industrial use.

Wm. Luscombe:[3] In the discussion of this subject, the speaker desires to stress the fact that it is so closely allied to and interwoven with that of waste and losses in the distribution system, one cannot fully discuss the first without considering the others, so he asks your kind indulgence for the latitude taken.

In determining the night rates as well as the day flows, he desires to emphasize the importance of first knowing the accurate quantities pumped or flowing into the force mains and distribution system, the

[1] Presented before the Indiana Section meeting, January 23, 1925.

[2] E. J. Jenkins, formerly with East Chicago Water Works; now with Philadelphia Suburban Water Works, Philadelphia, Pa.

[3] Vice-President, Gary Heat, Light and Water Co., Gary, Ind.

entire twenty-four hours. Regardless of what devices, apparatus, or methods are used, frequent accuracy tests and check-ups are essential, if correct information is always obtained.

In many cities and towns the total output is based upon the number of pump strokes, which are taken at face value. In other places allowances are made for slippage ranging from 5 to 20 per cent or more. Some years ago, the speaker was in charge of a plant where that method of computation was used. Five per cent allowance was made for pump slippage when he assumed charge. Shortly afterward, tests were made and 14 per cent slippage was found in one pump and 18 per cent in another. This condition is typical and "Old Man Slippage" is still doing a "kidding" business and his proportions are such an unknown quantity in many places that he is responsible for a vast amount of misinformation in recording the total water supplied.

In other places, and, no doubt, in many instances where special metering devices are used to record the total supplied or pumped, one might well question whether or not its efficiency equals approximately 100 per cent throughout the twenty-four hours. The showing may be all that could reasonably be expected under a day flow or a peak load rate and yet make a miserable record under a low night flow. This has been the experience of the speaker and he believes it is not uncommon. In justice to manufacturers, it should be stated that, on account of the wide range of conditions under which some metering devices operate, it is hardly fair to expect them to make a 100 per cent record all of the time.

When the actual amount of water pumped or flowing into the distribution system during the night time as well as during the day period has been accurately and definitely fixed, an analysis of what becomes of all of it may be in order. For the purposes of this discussion, remarks will be limited to that part of the demand made between midnight and 6:00 a.m. During 1924 our daily average pumpage was approximately 5,200,000 gallons, practically all taps are metered, and our population is about 80,000. The percentage of the total pumped per twenty-four hours, that passes out of the system between midnight and 6:00 a.m. during non-sprinkling months, ranges from 12.7 to 16.6 per cent and averages 15 per cent. These variations are due principally to changing business conditions, seasons of the year, etc. For instance, during extreme cold weather the night flow is increased as much as 20 per cent on account of

customers permitting faucets, etc., to run to prevent pipes and fixtures from freezing and bursting. On hot, dry evenings when lawn sprinkling is carried on extensively, the delivery per minute for short periods is six times as great as that of the latter part of the night flow which, however, is not affected by that use.

As mentioned, the demand for the six-hour period ending at 6:00 a.m. averages 15 per cent of the day's total (5,200,000 gallons) or 780,000 gallons. Our records show that an average of 84.5 per cent of total daily average pumpage or 4,394,000 gallons is registered by meters on customers' service pipes plus small miscellaneous uses. This leaves a balance of 806,000 gallons per day which we consider chargeable to "unaccounted for" or leakage in mains and services. To ascertain the estimated leakage in mains and services during the six-hour period, one fourth is taken of the 806,000 gallons, which is 201,500 gallons. If this amount is deducted from the total pumped during the six-hour period (780,000 gallons) there are left 578,500 gallons, or about 74 per cent of that total which it is estimated passes through customers' meters during that period.

According to inspections made, the principal users of water between midnight and 6:00 a.m. are: Industrial and ice manufacturing uses, locomotive tank filling, garages, dairies, bakeries, hospitals, industrial workers homes on account of time in changing shifts, lunchrooms, hotels and soft drink places.

Recently, it was found that about 20 per cent of the night flow was being registered by five meters of the users mentioned.

Of course, some of the foregoing list of users, as well as other customers, are also water wasters, as they permit such fixtures as faucets, drinking fountains, closets, urinals, etc., to run continuously, but as they pay for all water furnished by meter measurement, the waste inside of buildings is curbed to a great extent.

Granted we are paid our regular meter rates for all water furnished the consumer, we take the position that unsuspected waste paid for by him creates dissatisfaction and in a friendly spirit, we make it our business to show him, if we can, the cause of the high bill so that he will be better enabled to apply the proper remedy. We believe this coöperation and voluntary service is invariably appreciated.

Another form of waste that vitally interests us, of course, is that of the unmetered class, or losses in the distribution system and the best method of checking it.

We make frequent pipe line leakage inspections and, as many

leaks exist that give no surface indications, we have experienced men who use metal rods for sounding locations of mains and aquaphones to locate breaks.

We also ascertain the extent of the leakage into some suspicious sections of the distribution system by closing the gates, using the hose from one fire hydrant to another, and measuring the flow into the segregated section through a meter connected into the hose line.

We obtain very good results with both methods.

For extensive water waste surveys, no doubt, pitometer tests are far preferable.

In fairly comparing the percentage of that portion of the total pumpage term "unaccounted for," it should be borne in mind there is a great variation in the pressure carried in different cities and towns, and it is very important that this item be taken into account as well as other factors such as mileage of mains in their various sizes; number, size, and mileage of service pipes; percentage of taps metered, etc.

The speaker believes that the extent of distribution system losses or the percentage of water "unaccounted for" in any water plant depends largely on the interest displayed and action taken by those in authority, to check it, and that eternal vigilance and wise painstaking methods are absolutely essential if such losses are reduced and kept to a minimum.

J. O. Endris:[4] I am giving you herewith statistics which we have compiled for the past year on our properties at Jeffersonville, giving briefly percentage of consumption from midnight to 6:00 a.m.

We have especially accurate data on our Jeffersonville distribution system, inasmuch as all water being pumped into the city is being registered through a venturi meter at the pumping station. The percentage varies during certain months of the year and I am giving below the results of the twelve months past (1924):

	per cent		per cent
January	19	July	11
February	17	August	11
March	17	September	14
April	22.5	October	13
May	11	November	15
June	17	December	18

[4] Superintendent, Water Department, I. P. S. Co., New Albany, Ind.

This gives an average demand of 15.7 per cent. Therefore we know fairly accurately what percentage of water pumped from our wells are used during the hours mentioned above.

As to who uses this water we are not as sure for the following reasons. Jeffersonville is only 39 per cent metered, consuming 34 per cent of the water pumped during the year. The remaining 61 per cent is made up of flat rate consumers, consuming 66 per cent of the water pumped during the year. Of the water used through meters 20 per cent is used by industrials, and 14 per cent by domestics.

As I have shown above, for the various months of the year, it is apparent that our night demand is considerably higher during the winter months than it is during the summer. This we have readily accounted for, by the water wasted by consumers on flat rates. We find these consumers during cold weather very liberal in the use of water to save plumbers' bills and it is safe to say that at least 5 per cent of the average demand is made up in this way.

This we hope to overcome by the installation of meters throughout the city as soon as it can logically be done.

We have two railroads in the city who are also night consumers who take a fair percentage of this water. Certain manufacturers, especially two large manufacturers, carry a certain demand, the entire twenty-four hours of the day.

We find also from a study of the charts of the venturi meter that the demand materially increases about four o'clock in the morning. This we have reason to believe is brought about by the fact that a good portion of the Jeffersonville population is employed in Louisville with consequent early rising and the increased use of water.

We also know a certain part of this percentage is made up of loss through leakage in the distribution system, but just what the proportion is we are unable to ascertain at this time on account of the large percentage of flat rate consumers.

In New Albany, while the total consumption to this city is metered through a venturi meter at our stations, our meters are between the filtration plant and the clear well. Since delivery to the distribution system is by gravity, the variations in demand is taken care of in the basin, while the flow through the meter is constant, therefore no accurate method of getting an account of the night demand is possible. The average for the year approximates 25 per cent. This is higher than Jeffersonville, inasmuch as New Albany has several

large manufacturers who do seasonal business and one especially who, when operating during the winter months, uses large quantities of water through the entire twenty-four hours of the day.

New Albany is only 37 per cent metered, consuming however 55 per cent of the water pumped during the year, 20 per cent of this being by domestic and 35 per cent by industrial consumers. Sixty-three per cent of the city still remains on flat rate, who consume 45 per cent of the total water pumped during the year.

We have found by investigation and inspection that the waste of water by flat rate consumers is considerably less in New Albany than in Jeffersonville. However, we do not know what percentage of this is of the night demand, nor do we know what percentage of it is loss through leakage in the distribution system.

We are now working to the point where we may have accurate data, and that is 100 per cent meters to all consumers. When we have this condition we will be in a far better position to determine every phase of the consumption.

H. E. Jordan:[5] This discussion has value in that it serves to call attention to waste and its prevention.

At the New Albany plant the lack of meters reflects itself in the increased winter night load, while at East Chicago increased demand due to wastage on cold nights has been practically eliminated.

The effect of meters in the latter community is striking. In 1920, the unit consumption was 234 gallons. In 1924, it has been reduced to 138. Assuming the same industrial demand, the domestic and commercial demand had been reduced from 154 to 58 gallons.

It is important to point out the erroneous idea that may be conveyed by reference to crude per capita figures. East Chicago, now 100 per cent metered, has a total rate, 138 gallons, that appears high until it is pointed out that actual sales to industrial users accounts for 80 gallons of this amount, and leaves the total of 58 gallons for all other uses.

This, if it has deducted from it the municipal uses, practically coincides with the rational demand of 40 to 50 gallons per capita.

[5] Sanitary Engineer, Water Company, Indianapolis, Ind.

THE CAUSES AND PREVENTION OF RED WATER[1]

By Paul C. Laux[2]

Red water is the term applied to water which is discolored with iron, either due to the presence of iron in the natural water or to the corrosion of the iron pipes with which the water comes into contact. Everyone is familiar with the iron stains on sanitary sinks and enameled bathroom fixtures, and this objectionable feature of the water, every good housewife will claim, is enough to condemn it unless the cause for the stains is removed.

If the red water is due to iron in the natural water only, then this is practically the only objection to it, and it can be corrected by one of the various iron removal plants. A water softening plant in the usual lime treatment of the water will remove the iron, as will also an aeration and filtration plant. Both systems depend on the oxidation of the soluble ferrous hydroxide to the insoluble, and therefore removable, ferric hydroxide.

When the natural water is free from iron and the water from the taps has the reddish color caused by iron, one meets a more serious problem, for here the trouble is due to pipe corrosion, and besides the staining qualities and unsightliness of the water, the life and the carrying capacity of the water mains are affected. Even though the corrosion goes on so slowly that its effect on the life of the pipes is not noticeable, it is bound, by its deposition of rust, to greatly reduce the carrying capacity of the pipes.

In a paper on Causes and Correction of Red Water by Thorndike Saville before the North Carolina Section of the American Water Works Association, last year, the speaker made this statement: "One may say that, when one-twenty-seventh the thickness of the wall of a $1\frac{1}{2}$-inch iron pipe, or one-fortieth of the thickness of the wall of a 1-inch iron pipe is corroded the pipe is completely choked up." So, if it were unnecessary to prevent corrosion for any other reason, its effect on the carrying capacity of the pipes alone, would make a remedy compulsory.

[1] Presented before the Iowa Section meeting, December 2, 1925.

[2] National Lime Association, Chicago, Ill.

In order to understand just how corrosion takes place an elementary explanation of hydrogen ion concentration, or pH values, is necessary. Water dissociates very slightly into positive H ions and negative OH ions. The amount of these dissociated ions is very small. In pure water the amount of free hydrogen is 1 part of hydrogen to 10 million parts of water. The amount of free hydrogen in the water is called the hydrogen ion concentration, and this hydrogen ion concentration is expressed in terms of the pH value of the water. The concentration of hydrogen ions in distilled water is given a pH value of 7.0, based on the seven zeros in 10,000,000. If the water has a hydrogen ion concentration of 1 part of hydrogen to 100,000 parts of water, then the pH value would be 8.0, likewise a concentration of 1 part of hydrogen to 1,000,000 parts of water would give the water a concentration of a pH value of 6.0. Since pH 7.0 is the value of a pure water, this point is called neutral, and a water with a lower pH value is an acid water, because the presence of any acid radical will increase the amount of free hydrogen in the water, and a water with a higher pH value is an alkaline water, because any alkaline radical will decrease the ability of the hydrogen ions to dissociate. We might then define hydrogen ion concentration as the amount of hydrogen ions that are dissociated in the water, while pH value might be defined as an inverse expression of the hydrogen ions, based on the number of million parts of water necessary to produce one part of hydrogen. pH values below 7.0 indicate acid waters, while pH values above 7.0 indicate neutral waters.

This dissociation of water, or hydrogen ion concentration has a direct bearing on the corrosion which takes place in water mains, because the iron is very slightly soluble in water, the solubility depending on the dissociation of the water into hydrogen (H) ions and hydroxyl (OH) ions, so that the following reaction takes place:

(1)	Fe plus	2HOH equals	$Fe(OH)_2$ plus	2H
	iron	water	ferrous hydroxide	hydrogen

The hydrogen will form a film over the iron and prevent further corrosion, unless it is disturbed. Most water supplies, however, contain dissolved oxygen, which absorbs the hydrogen to form water, according to the following equation:

(2)	2H	plus O	equals HOH
	hydrogen	oxygen	water

This oxygen also oxidizes the ferrous hydroxide, as formed in equation one, which is soluble in water to the insoluble ferric hydroxide.

(3)	$4Fe(OH)_2$	plus	$2O$	plus	$2H_2O$	equals	$4Fe(OH)_3$
	ferrous hydroxide		oxygen		water		ferric hydroxide

This ferric hydroxide, or rust, may be deposited on the surface of the pipe and prevent further corrosion. It is a rather unstable covering, however, and is more readily removed in acid waters than in alkaline waters. The reason for this is rather involved, but it again depends on the hydrogen ion concentration. As previously stated, the pH value of acid waters is low, therefore the amount of hydrogen ions is great. If the dissociation of the water is slow, as it is in alkaline or nearly neutral waters, it forms a film around the iron pipe or the corrosion, but if it is rapid, as in acid waters, then the hydrogen gas escapes, and the equilibrium of the reactions is broken, and since both hydrogen and iron are positive radicals, iron is required to replace the hydrogen.

The prime factors in corrosion, then, are hydrogen ion concentration and dissolved oxygen. However, we must not overlook the action of free carbon dioxide in the water, Most natural waters contain free carbon dioxide due to the decomposition of organic matter, and this amount is increased by the action of alum when it is used as a coagulant, as will be explained later. Where free carbon dioxide exists in the water, it unites with part of the water and forms a weak acid known as carbonic acid

(4)	CO_2	plus	HOH	equals	H_2CO_3
	carbon dioxide		water		carbonic acid

It has already been stated that in an acid water the hydrogen ion concentration is greater than in a neutral or alkaline water, and corrosion increases with hydrogen ion concentration. It has also been brought out that the protective rust film formed is less stable in acid than in alkali waters, so that by causing acid conditions in the water, carbon dioxide has a twofold effect in increasing the rate of corrosion.

1. It increases the amount of ionized hydrogen in the water.

2. It weakens any protective coating of iron rust that may be formed.

Besides these two factors, however, carbon dioxide has another effect on corrosion. When it forms carbonic acid by uniting with water it adds a solvent for the iron according to the following equation:

(5)	Fe	plus	H_2CO_3	equals	$FeCO_3$	plus	$2H$
	iron		carbonic acid		iron carbonate		hydrogen

This iron carbonate is then acted upon by dissolved oxygen in the water as follows:

(6)	$4FeCO_3$	plus	$2O$	plus	$6H_2O$	equals	$4Fe(OH)_2$	plus	$4CO_2$
	iron carbonate		oxygen		water		ferric hydroxide		carbon dioxide

It is to be seen, from this equation, that the carbon dioxide is again liberated and ready to start all over again with fresh iron from the pipe, so that a small amount of carbon dioxide will cause a considerable amount of corrosion.

Obviously then, when trouble exists due to corrosion, one thing to do is to get rid of the free carbon dioxide in the water. If the water is aerated, most of the carbon dioxide is removed, but the dissolved oxygen content is usually increased in this operation, adding to a condition which is in itself already corrosive. If an alkali, such as lime, is added to the water, the free carbon dioxide is absorbed, forming calcium bicarbonate, as follows:

$$(7) \qquad Ca(OH)_2 \text{ plus } 2H_2CO_3 \text{ equals } CaH_2(CO_2)_2 \text{ plus } 2HOH$$

Soda, ash, caustic soda, or any other alkali would have the same effect as lime, but lime is the most economical remedy. J. W. Ledaux, in the Water Works Issue of Engineering and Contracting, January, 1925, states that $1.00 worth of lime is as effective as $3.27 worth of caustic soda, or $5.65 worth of soda ash.

The amount of carbon dioxide that must be removed varies with the nature of the water. At Baltimore, Md., this treatment is based entirely on pH control. The pH value aimed at is between 7.2 and 7.4. As lime is added the hydrogen ion concentration is reduced, due to an increase in the alkalinity, while the pH value is raised. Leeds and Northrup have installed there a potentiometer which records the pH value by means of colored lights. When a red light appears, the pH value is too low and the amount of lime

added is increased. In the same manner, when a blue light appears, the pH is higher than is necessary to prevent corrosion, and the lime dosage is decreased.

While it is generally accepted that carbon dioxide corrosion can be prevented by raising the pH value to a point above 7.0, still many waters high in carbonate hardness and therefore alkaline, may be corrosive due to an excessive amount of free CO_2, and a lime, or other basic treatment, is required to reduce this carbon dioxide content to a point below the aggressive. Every water brings its own individual problems and it is impossible to set a hard and fast rule as to the pH value or the amount of free carbon dioxide permissible without causing corrosion in all waters. However, if red water troubles due to corrosion exist, chances are that there is too much free carbon dioxide in the water, and the addition of an alkali will correct this condition.

Alkalinity exists in water as magnesium and calcium bicarbonates. The normal carbonates are insoluble in water, but since most natural waters contain free carbon dioxide, which forms carbonic acid, the normal carbonates are changed to bicarbonates according to the following equation.

(8)	$CaCO_3$	plus	H_2CO_3	equals	$CaH_2\ (CO_3)_2$
	calcium carbonate		carbonic acid		calcium bicarbonate

If lime is added to water containing calcium bicarbonate in excess of the amount required to absorb the free carbon dioxide present, then the following reaction takes place:

(9)	$CaH_2\ (CO_3)_2$	plus	$Ca(OH)_2$	equals	$2CaCO_3$	plus	$2HOH$
	calcium bicarbonate		calcium hydroxide		calcium carbonate		water

The normal carbonates, being insoluble, are deposited as a fine coat on the pipe and protect the iron from the water, and thus prevent corrosion. However, when this coat is formed, water with free carbon dioxide will again change this coat to the bicarbonate and remove it, the bicarbonate being soluble in water. Therefore, even if a protective coating is formed on the pipe, carbon dioxide removal is still necessary to protect the coating as well as the pipe.

Where to apply lime for correcting corrosive qualities of water is another problem. In some cases it is added directly with the alum,

i.e., ahead of the mixing and sedimentation. However, in some cases the water is of such nature that the lime will interfere with the coagulation, if added in this manner. A point in case is at Akron, Ohio. Here the lime was added, first ahead of mixing, then after mixing and ahead of sedimentation, next it was added ahead of the filters, but after sedimentation. There were objections to all of the points of application, and now the milk of lime is added to the clear well under a unit of five filters and is mixed with the water from twenty other filters in the conduits leading to the suction well, and in the suction well itself.

This treatment has eliminated all red water trouble and main corrosion, and has not given rise to any evils, such as after-deposits. According to Mr. Gettrust, the chemist in charge of the Akron plant, the only people not pleased with the water since this treatment was inaugurated, are the plumbers.

Another instance where lime is added to the water to absorb free carbon dioxide is at Hannibal, Mo. Here a new plant has been built and just recently put into operation. When I visited there, the plant had not been completed, but the plan of treatment was about as follows. The water was to be treated with sulphuric acid for color removal, and alum was to be used for coagulation. Both of these treatments increase the sulphate hardness of the water, and therefore must liberate free carbon dioxide, so that a lime treatment will be necessary to remove this water from the corrosive class. Mr. Wolf, the chemist, figures on adding the lime into the suction end of the pump which will lift the water from the filtered water reservoir into a storage reservoir of several million gallons capacity, from which the water will be distributed throughout the city mains. At Evansville, Ind., the lime is added just ahead of the filters, giving very good results, while at Baltimore, Md., the lime is added to the conduit leading from the filters to the clear well.

Surface waters that are used for city water supplies contain turbidity that must be coagulated before the water can be properly clarified by sedimentation and filtration. For this purpose alum is used in most instances. The action of alum, or aluminum sulphate depends on its changing from the sulphate form to aluminum hydroxide. In this process, part of the alkalinity or carbonate hardness of the water is changed to sulphate hardness, while the carbonate radicals are liberated as carbon dioxide. Thus in treat-

ing water with alum, the free carbon dioxide content, and therefore the corrosive tendency of the water is increased.

The carbon dioxide content of the water is measured by using phenolphthalein indicator. If the water gives even a very faint pink color when the indicator is added, then no free carbon dioxide is present. If, however, the water remains colorless upon the addition of a drop or two of N/50 sodium hydroxide, then free carbon dioxide is present and the amount of the sodium hydroxide required to give the water a pink color solution indicates the amount of free carbon dioxide in the water.

To see what the action of alum on free carbon dioxide content of water is, take a sample of water, add a few drops of phenol indicator, and sufficient N/50 sodium hydroxide to bring about a faint pink color in the water. The number of cubic centimeters of solution required to bring about this color change multiplied by 10 will indicate the parts per million of free carbon dioxide in the water. Now take another sample of the water and add to this sample several grains per gallon of alum, mix thoroughly and filter part of it and titrate in the same manner. The increase in the content of free carbon dioxide measures the amount of gas set free by the action of the alum on the carbonate hardness of the water.

To demonstrate that it is free carbon dioxide that has been absorbed until the pink color appears in the water, blow through a glass rod or pipette into the cylinder containing the colored water, first adding enough sodium hydroxide solution to bring about a deeper color, so that the change will be more distinctive. As one exhales through the tube, carbon dioxide is introduced into the water, and the pink color disappears.

This determination is based on the fact that normal carbonates are indicated by the phenol color in the water, when no normal carbonates are present, the water remains colorless. As sodium hydroxide is added to the water, it is changed by the free carbon dioxide to sodium bicarbonate. Just as soon as all of the carbon dioxide has been consumed, the bicarbonate will give up its excess radical or carbon dioxide to the sodium hydroxide and both will form normal carbonates, and the pink color will appear. Then as carbon dioxide is again added, the normal carbonates are changed to bicarbonates, and the color disappears.

It has already been pointed out that the addition of alum changes the bicarbonates to sulphates of calcium and magnesium. Pre-

sumably then it is possible to have a condition where the alkalinity is so low that not enough bicarbonates are present to react with the water. When aluminum sulphate is added to an alkaline water, the following reaction takes place.

(10) $Al_2(SO_4)_3$ plus	$3CaH_2(CO_3)_2$ equals	$3CaSO_4$ plus	$2Al(OH)_3$ plus	$3CO_2$
aluminum sulphate	calcium bicarbonate	calcium sulphate	aluminum hydroxide	

Each grain of alum required to flocculate the turbidity in a water destroys about ½ grain per gallon of alkalinity in this manner. If insufficient alkalinity is present, the alum must hydrolize into sulphuric acid and aluminum hydroxide, which is a rather slow process and gives rise to slow and unsatisfactory coagulation. If lime is added in sufficient quantities to completely satisfy the alum by increasing the alkalinity, then better and quicker coagulation results. This action is shown in the following equation:

(11)	$3Ca(OH)_2$ plus	$Al_2(SO_4)_3$ equals	$2Al(OH)_3$ plus	$3CaSO_4$
	calcium hydroxide	aluminum sulphate	aluminum hydroxide	calcium sulphate

WATER SUPPLY CONDITIONS IN MISSOURI[1]

By George W. Putnam[2]

Water supply conditions in Missouri are perhaps the most varied of any middle western state, owing to the pronounced differences in topography and geological formations. Portions of the state are located in three distinct physiographic divisions. The Missouri River flowing from west to east roughly bisects the State. The north half, together with two areas south of the River, is situated in what geographers have classified as the Interior Plains of the United States. (See figure 1.) Illinois, Iowa, South Dakota, Nebraska and Kansas are also situated in this physiographic division. Owing to the highly mineralized character of much of the ground water obtained in this section of Missouri, the majority of the cities obtain their water from surface sources, including rivers, streams and impounding reservoirs.

The extreme southeast portion of the State is situated in what is termed the Atlantic Coastal Plain. This section formerly contained considerable swamp land which has been drained and planted extensively in cotton, giving excellent yields. Cities in this section obtain their water supply from wells. The majority of these penetrate only the upper stratum of sand and gravel and are of comparatively shallow depth.

The portion of the State south of the Missouri River, with the three subtractions above noted, is situated in the division known as the Ozark Plateaus. Cities in this section obtain their water supply principally from deep wells drilled in rock. A few are obtained from springs and mines. Some of the largest springs and caves in the United States are located in this district.

SURFACE WATER SUPPLIES

Considering first the surface water supplies, we naturally find that the seven cities over 15,000 population, namely, St. Louis,

[1] Presented before the Iowa Section meeting, December 3, 1925.

[2] Chief Sanitary Engineer, State Board of Health of Missouri, Jefferson City, Mo.

Kansas City, St. Joseph, Joplin, Springfield, Hannibal, and Sedalia, are using surface water, being compelled to do so to secure the necessary volume economically. Fourteen out of twenty-two cities from 5000 to 15,000 population are also supplied with surface water. The striking feature is the fact that fifty-two cities under 5000, out of the 171 having water supplies, are compelled to use a surface water supply from streams or impounding reservoirs. With five exceptions all of these towns are located in the Plains district, the reason being,

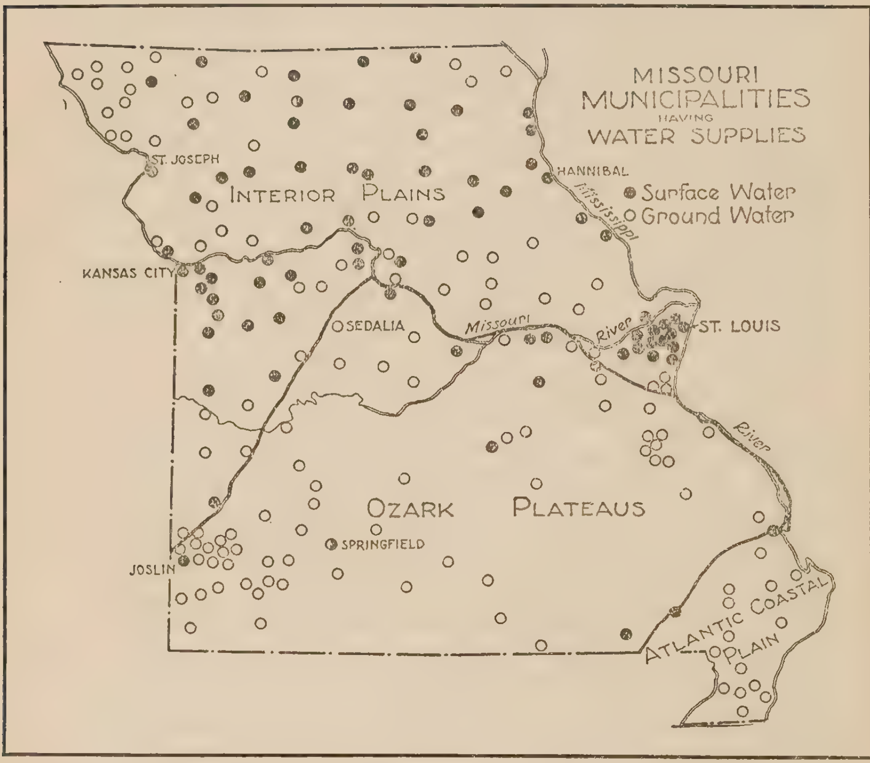


FIG. 1

as mentioned before, that most of the well water in this district is so highly mineralized that it does not constitute an acceptable domestic supply. Where a city of 2000 population in the Ozark section can secure a deep well supply for $5000 to $10,000 outlay, a north Missouri city in the Plains district is usually compelled to spend from $30,000 to $60,000, to obtain a surface water supply from an impounding reservoir or stream, and to provide a filtration plant to purify it.

Several cities in the Plains district, as for example, Clinton, Edina, Holden and Higginsville, within the past three years have abandoned a highly mineralized well supply, containing hydrogen sulphide gas and excessive hardness and have provided a soft filtered water of low mineral content from a surface source.

Twenty-nine cities are supplied with purified water from the Missouri and Mississippi Rivers. The pollution of these rivers is considerable, as is evidenced by the fact that the Missouri River water at the Kansas City intake contains an average of about 6800 B. coli per 100 cc.; the Mississippi River water at Quincy, 1700; and the raw water from both rivers at St. Louis, 3700. It will be noted that these B. coli counts are materially in excess of the limit for safe loading of filter plants without chlorination, namely, 650 per 100 cc., suggested by H. W. Streeter, Sanitary Engineer of the United States Public Health Service. This suggests the possible necessity in the future of a comprehensive sewage treatment program for the cities on these rivers in Missouri and other states upstream to lessen, or at least to prevent, an increase in the pollution load on water plants obtaining their supply from these rivers.

Of the sixty-six surface water plants in the State, thirty-six have complete filtration plants; four are complete except for chlorination; eleven have coagulation, settling and chlorination; and fifteen have either less complete or no purification. No great difficulty has been experienced in purifying surface waters in Missouri, with the aid of final chlorination, accurately controlled with the o-tolidine or similar test for free chlorine, so that the finished water will conform to the Treasury Department Standard for safe drinking water.

The past few years has developed considerable activity in enlarging and improving the water purification plants in the State. Filtration plants have been completed in the last four years in Canton, Clinton, Edina, Flat River, Glasgow, Hamilton, Hannibal, Higginsville, Holden, Kirksville, Milan, Moberly, and Trenton. Other major improvements to surface water supplies have been completed in recent years at Cameron, Chillicothe, King City, Paris, Shelbina, Springfield and Valley Park. New filtration plants are now under construction in St. Louis, Kansas City, Jefferson City and LaPlata. Extensive improvements are being made at Sedalia.

The need of an organization of waterworks men having charge of purification plants in the State has been evident. On October 26–27 of this year, the State Board of Health called the first Missouri

Conference on Water Purification. The meeting was well attended and a lively interest was shown in the papers and discussions. A permanent organization was formed to hold an annual conference meeting and to serve as a clearing house for information of benefit to the members.

The importance of careful operation of water purification units has been forcibly demonstrated twice in Missouri, since the sanitary engineering service was established in 1922 by the State Board of Health. In February, 1923, the railroad drew heavily upon the local waterworks at Louisiana, so that the rate of filtration one day had to be increased some 50 per cent. The chlorine dosage was not increased, or a proper test for residual chlorine maintained, and the following day a widespread epidemic of diarrhoea occurred. The water is obtained from the Mississippi River and the pollution load is considerably in excess of the suggested safe loading limit mentioned above for filtration alone.

Pierce City recently voted bonds for the installation of a deep well to permit abandonment of the existing contaminated spring supply. However, this wise provision for the future did not protect the existing supply, and when laxity in keeping the chlorinator in continuous operation recently occurred, an epidemic of twenty-two cases of typhoid with two deaths followed.

GROUND WATER SUPPLIES

One hundred and nineteen of the 185 water supplies, or approximately 65 per cent, are secured from ground water sources. The majority of these supplies are obtained from deep wells drilled in rock. This water is from either limestone or sandstone and is moderately hard, but always of acceptable physical and chemical quality when obtained in the Ozark district. Those supplies obtained from shallow wells in sand or gravel strata usually contain excessive quantities of carbon dioxide gas and iron. Supplies of this character are treated successfully in iron removal plants at Caruthersville, Excelsior Springs, Kirkwood and Liberty. A fifth plant is now being installed at Salisbury.

Ground water supplies are also obtained in a few instances from springs, mines and infiltration galleries. All surface spring supplies used by municipalities are contaminated at intervals with surface water and require treatment. Five municipalities are supplied with water from lead mines in St. Francois County, the largest lead produc-

ing mining field in the world. One supply is from a spring in a mine. This water is of excellent sanitary quality and is used without treatment. The other supplies are furnished with mine water, draining mainly from working levels, purified by filtration and chlorination. The ore occurs in the form of galena which is a sulphide of lead and is insoluble in the water. There have never been any cases of lead poisoning among the miners or among residents drinking the water.

SANITARY PROTECTION OF GROUND WATER SUPPLIES

Experience in Missouri indicates that there are many sanitary defects in connection with ground water supplies which have in the past caused the intermittent infection of otherwise safe supplies, and that many municipalities have had a false sense of security regarding the safety of their supplies, due to the popular idea that all ground water has received complete natural purification. As a matter of fact there are records of more epidemics occurring on ground water supplies in the State in the past than on surface water supplies. Underground pollution of wells and springs with surface water takes place through the fissured, shattered limestone strata of the Ozark section unless carefully guarded against. A striking example of the open character of the limestone strata in many portions of southern Missouri is illustrated in the case of the Springfield water supply. The main source of supply is a large spring located at the base of a hill. Water of recent surface origin gains access to the spring through sink holes and fissures in the outcroppings, and for this reason a complete filtration plant has been provided for purification. The flow of this spring is not sufficient at some periods of the year, and the supply is supplemented by water from either deep wells or from a 125,000,000 gallon impounding reservoir, which is located four miles from the spring. The unusual point is that no pipe line connects the reservoir to the purification plant. A pipe carries the water only a quarter of a mile below the impounding reservoir, where it discharges into an opening in the limestone, and the water travels underground through solution channels in the rock to the main spring, taking from four to six hours for the journey.

A careful study of the sanitary defects permitting the contamination of ground water supplies in Missouri has been made by the State Board of Health and the necessary safeguards established. This information was incorporated in a comprehensive detailed report of the Committee of the Conference of State Sanitary Engineers on

Sanitary Control in the Development of Ground Water Supplies, adopted at their 1925 meeting in Louisville, Ky.

In the case of deep wells drilled in rock, and particularly in the fissured limestone strata, the recommended specifications of the State Board of Health (see appendix A) require the casing extended and sealed below all openings or soft or broken ground. Samples of each screw are saved by the driller and submitted to the State Geologist, together with a carefully kept log of the well, in order to insure that the casing is extended deep enough to shut off all surface contamination. Bacteriological examinations even reveal a few instances in which properly constructed wells of considerable depth are located in such deeply fissured rock that contamination reaches them. In these instances purification is adopted. An old city well at Monett tapped an underground lake, the water in which became turbid after rains. In 1914, a devastating typhoid epidemic resulted. Now, they have three wells in a fairly solid formation, but chlorinate all the water as a factor of safety.

GENERAL DATA

The total number of incorporated municipalities in Missouri supplied with water from public water supplies totals 200. In some instances two or more municipalities are supplied from a single source. In addition, there are two supplies furnishing water to unincorporated districts alone, so that the actual number of public water supplies in Missouri totals 185. The number, and percentage of total number, of cities in various population groups having water supplies in Missouri is given below:

	OVER 2500	1000–2500	UNDER 1000
Total number cities in class	65	118	530
Number having water supplies	65	87	48
Percentage having water supplies	100%	74%	9%

It will be seen that, in common with her neighboring states, Iowa and Kansas, Missouri has no towns over 2500 without waterworks.

With reference to fire protection, the Missouri Inspection Bureau, representing the fire insurance underwriters, have rated 166 of the incorporated municipalities having public water supplies. The number of towns in the different ratings, as tabulated by this Bureau, are given below:

Missouri Standard—Class	1½	2	2½	3	3½	4	4½	5
Number of cities in class	1	1	1	1	8	19	98	37

In explanation of the large number of towns occurring in the $4\frac{1}{2}$ and 5th class, it might be explained that the $4\frac{1}{2}$ class is about the highest that it appears economically feasible for the smaller cities under 5000 population to maintain at the present time.

Many municipalities in Missouri under 2500 population are greatly in need of public water supplies for fire protection and convenience purposes. In the majority of these cities, there is also a pressing need for a safe municipal water supply for sanitary reasons, as shallow wells or cisterns are generally contaminated with surface, shallow ground water, and waste water from the pumps. The studies and experience of the State Board of Health on epidemics have convinced them that a safe public water supply is a paying investment to the average city from a health point of view alone. In 1921, Potosi, a town of 1000 population, suffered from a water and filth-borne typhoid epidemic which resulted in fourteen deaths. Fourteen lives at $5000 each totals $70,000 economic loss in a single year. This exceeds the cost of a waterworks system to serve the town.

The State Board of Health is lending active encouragement to the installation of new waterworks and sewerage systems through sanitary surveys, analyses of private water supplies, and educational talks given at mass meetings of citizens or civic organizations. In the past three years, twenty-two towns have installed new waterworks and forty-seven have made necessary sanitary improvements thereto.

The bounding limit for cities under 30,000 has been successively increased from 5 to 10 per cent of the assessed valuation, and then to 15 per cent in 1920. The bonded indebtedness for sewers and other city debt must not exceed 5 per cent, leaving 10 per cent for waterworks, electric light, and ice plant, in case 5 per cent has already been voted for sewers or other city debt.

One difficulty in securing the installation of waterworks systems is that a bond issue must have a two-thirds majority of all those voting. While this seems quite a barrier to clear at the start, most cities, when the bond issue has been defeated at the first election, have passed it by good majorities at the second election by thoroughly organizing their campaign to get out the favorable votes. The average majority vote of those bond issues carried in the past two years has been over seven to one. In 1923, Festus, population 3348, rolled up the nearly unanimous majority vote of fifty-five to one, for a bond issue of $175,000 for complete waterworks and sewer-

age systems. This was accomplished by a spirited citizen's campaign, in which the State Board of Health coöperated.

SUMMARY

In conclusion, water supply conditions in Missouri are quite varied owing to topographical and geological differences within the State. An unusually large percentage of the municipalities are supplied from surface sources, particularly among the smaller cities owing to the highly mineralized character of the ground water in the Plains district of the State. Ground water supplies obtained from fissured limestone in the Ozark district must be carefully safeguarded to prevent their contamination with surface water, or adequately purified. Real progress is being made in establishing new water supplies in the smaller cities, in securing essential improvements to existing supplies, and in improved operation of water purification plants.

APPENDIX A

State Board of Health of Missouri

RECOMMENDED SPECIFICATIONS ON SANITARY PROTECTION FOR WELLS DRILLED IN ROCK

1. At least one week before starting to drill the well, the driller shall send a written request to the State Geologist, Rolla, Missouri, who will furnish a set of small sacks and a drill record book, and advise the depth of casing advisable to effectively shut out contaminated surface water from the well, based upon available records.

2. The well driller shall save a sample of cuttings from every screw and place same in the sacks properly labeling same. The driller shall note in the drill record book the location and depth of any openings or soft or broken ground.

3. When the well has been drilled to a depth equal to that of the recommended depth of casing, the driller, when requested, shall forward the samples of cuttings and record book to the State Geologist for examination.

4. The well shall be cased with a screw joint steel or wrought iron pipe installed in a watertight manner. This casing shall be extended past all openings or soft or broken ground and at least 10 feet into solid rock.

5. A satisfactory seal shall be made or installed at the bottom of the casing, by one of the following methods:

a. Setting bottom of casing in drill cuttings of a cementing character on a shoulder in the well made by reducing the size of the drill hole.

b. Driving casing into clay, shale or similar sealing formation.

c. Cement grout.

d. Lead packer.

e. Expanding rubber packer.

The seal shall be tested by bailing out the drill hole and making sure that there is no leakage into same over a period of forty-eight hours. When no appreciable amount of water has been encountered up to time of sealing, at least 1000 gallons of water, or as much as can be, shall be run into the annular space on the outside of the casing to test the seal.

Complete information on the depth of casing, method of sealing same, and result of test of seal shall be written in the drill record book.

6. The well casing shall be extended to a point from four to six inches above the elevation of the finished pump room or pump pit floor, and shall be provided with a thread at the top.

7. On completion of the well, the driller shall forward all samples of cuttings and the drill record book to the State Geologist, who will correlate same and furnish the owner with a copy of the completed log of the well.

WATER BUREAU INTERESTS DURING THE CONSTRUCTION OF THE NORTH BROAD STREET SUBWAY, PHILADEPHIA[1]

By S. M. Van Loan[2]

A monumental structure within the limits of a city or in any congested area will impose numerous inconveniences upon persons or interests located within the construction area. Protests from a minority must be met in a courteous way, but progress must not be stopped and often the areas involved by the activities experience hardships.

The Bureau of Water has been the recipient of many complaints where a distribution of water is modified or adjusted. A reduction of pressure, a suspension of service and a taste or odor, the latter imagined or not, have been mainly the type of protests registered in the department. On one occasion the failure of a large main deposited such a volume of water in a freshly excavated section of the subway work that sustaining embankment back of sheeting gave way, but early attention corrected this loss of support and normal conditions were soon restored.

To visualize the water distribution system and its relation to Broad Street where the present work on subway construction is active, it is in order to digress from the main subject and outline briefly a history covering location and water lines involved.

An early means of furnishing water to Philadelphia was through a pumping station located and built during the year 1799 on the Schuylkill River at Chestnut Street. Here an engine of $1\frac{1}{2}$ m.g. capacity pumped through a circular brick conduit built on Chestnut Street to Centre Square on which now stands the Public Buildings—City Hall—at Broad and Market Streets. The latter building, with a pumping installation of 1 m.g. capacity, was erected on Centre Square in 1801 and was removed during 1829 at which time a supply of water was being furnished from the Fairmount Works.

[1] Presented before the 4-State Section meeting, December 17, 1925.

[2] Assistant Chief Engineer, Bureau of Water, Philadelphia, Pa.

The construction of the subway under the existing City Hall uncovered sections of the masonry flume referred to above and excavations on Chestnut Street have at times involved this old structure.

Following the Fairmount Works there were built in 1848 those located at Girard Avenue, called the Spring Garden Works. From both were pipe lines conveying water to reservoirs and from the latter 48, 36- and 30-inch mains were laid to furnish with a supply of water the rapidly growing city.

A glance at the map of Philadelphia will disclose Broad Street, the location of which marks closely a midway line between the Schuylkill and Delaware Rivers—for a length of approximately seven miles. Further observation shows the street system developed with those two main thoroughfares forming somewhat a means for transit and utility convenience.

Market Street being laid out at an earlier date has borne cars on its surface from and including the horse drawn period to date, but a recognition of Broad Street as an attractive avenue for vehicles has kept it generally clear from surface or elevated common carriers.

Approaching the year 1900 the largest water pipe occupying Broad Street was 30 inches in size. A number of smaller mains were laid for the consumers' service and due to the roadway width these were placed on each side, but not under the footways.

With the construction of the filtration system a radical change was planned for the supply of water east of the Schuylkill River. An impressive addition to the water works included a large filter plant at Torresdale with an imposing pumping station at Lardner's Point from which Delaware River water would be delivered through an extensive pipe system for express and service purpose. The existing mains had been designed to distribute a supply of water pumped from the Schuylkill and much of this system continued to function as trunks for the passage of water from the Delaware source, all of which made necessary a reverse flow through the mains. Such a design for a distribution system was far from ideal and considerable distortion was practiced to effect a flexible system. The filtration planning contributed to Broad Street a 48-inch trunk main and upon the water introduction to the new design, the distribution system was functioning with a draft of 65 and 35 per cent respectively from the Delaware and Schuylkill Rivers. During the last two decades a pipe system for fire fighting purposes was added throughout a considerable length of this same street. This main is 12 and 20 inches

in size and with the connecting fire hydrant lines contributed an additional structure to maintain.

The studies on subway construction offered the Bureau of Water the opportunity to iron out some of the pipe installations which had resulted from a time-to-time addition, a record of such connections being only in the minds of former employees.

Generally a policy was adopted to remove and relocate the large mains lying parallel with the longitudinal axis of Broad Street and to raise those of the important trunks which were on intersecting streets. An early policy adopted on one contract held to hanging the service mains from the deck of the timber bridge which formed the vehicular surface. The vibration due to the passage of trucks and cars and the shock imposed by the use of dynamite caused innumerable breaks which became a general nuisance to the contractor excavating below decks and likewise the loss of water to the householder and business plant raised a storm of protests. A general laying of new pipe was resorted to in a location adopted under the footway and the new line was charged before the services were transferred. This method of operation was extremely satisfactory and much confusion was eliminated. On such sections where large mains were crowded out a parallel street was selected to provide a location for new pipe. A section of the work through a congested area will not admit of this transfer and it is purposed to relay a 48-inch main over the masonry roof of subway—reducing at station locations to twin 36-inch mains.

The high pressure fire lines were moved to a location generally under the footway, requiring also the relocation of many fire hydrants. No breaks have occurred on this system of piping and during subway construction the line has been supported on 12 × 12 posts.

One break of a serious nature has occurred on large pipe, where active work was under way on a 48-inch crossing Broad Street, the location of which required a radical adjustment to permit the passage of the subway. The break took place at an hour when workmen were few and the subsurface supports took splendid care of the flood.

The raising of a section of 48-inch steel pipe marked an unique piece of work. The elevation of this pipe was low for the subway section which in turn could assume no lower level due to the existence of a trunk sewer over which it must pass. During the activities of the existing contracts there have been involved 26,000 lineal feet of 48,

36- and 30-inch pipe together with 64,000 lineal feet of 12-inch and smaller, all of which construction has been executed by the contractors' force under expert inspection.

The Water Bureau assigned selected men to handle valves in case of trouble and a most harmonious coördination with the construction interests has been in effect. Where lines were relaid holding to equal sizes, the expense of pipe and laying was borne exclusively by the Transit Department. In the event of a larger main being planned such as the service mains which were formerly six inch, the Bureau of Water met the difference in cost. Pipe of all descriptions have been encountered: bored wooden logs laid prior to 1820 and cast iron pipe brought from England, some of which were imported as early as 1817. The following were the domestic contributions of cast iron bell and spigot; cast iron flange; cast iron universal and steel. The handling of each and all has placed no unusual burden on the Department's force and many times during this construction incidents have happened which have injected a humorous cast to the outsider looking on. There might be reference to the consumer, even though notified, who, finding no water in his fixtures, due to a shift of service, left home and upon returning discovered a modest flood; there might be reference to the general protest along certain sections, of unskillful operation of the city's filter plant and the careless use of chemicals which gave an odor and taste to their water; and reference might also be made to the consumer who has suffered a loss of service due to the sawing off and appropriation by persons unknown of the temporary lead services exposed, but hidden below decks. All were insignificant occurrences to us in general, but of extreme moment to the individual or interests involved.

The informal and modest reference to this work is in no way intended to minimize its importance and problems have been met and solved and more are to be encountered. Similar planning for the provision of water service has been affected for a continuation of the subway to the south of City Hall.

No large work can proceed with any satisfactory progress without skillful management and coördination of interests concerned and the writer takes great pleasure in referring to the splendid way in which the contractors have executed their work and the generous way all concerned have contributed their efforts.

CHLOROPHENOL-LIKE TASTES IN BAY CITY'S FILTERED WATER SUPPLY

By Louis B. Harrison[1]

An understanding of the underlying factors which cause the chlorophenol-like tastes in the Bay City water supply, requires a short historical account.

During the year 1916, Bay City was supplied with water by two separate pumping stations, one pumping water from the Saginaw River and supplying the east side, and the other from the Saginaw Bay supplying the west side.

Owing to the constant outbreaks of typhoid fever, the City Water Department resorted in 1916 to liquid chlorination as a safeguard against water borne diseases.

Along the latter part of the fall of 1916, peculiar chemical tastes appeared in the water supply. The consumers, knowing that the water was being treated with chlorine, blamed this chemical for the tastes. The same year, during the winter months, fishermen reported that the fish were dying in the Saginaw River and Bay by the thousand, and that the fish had a peculiar chemical taste.

To locate the source of the trouble, samples of water were collected from different points along the Saginaw River and Saginaw Bay. All raw water samples collected at that time had a distinct phenol-like, or medicinal, taste.

Figure 1 will show the number of streams which empty into the Saginaw River. All industrial wastes and sewage from the different cities located along these streams are eventually dumped into the Saginaw River, which in turn empties into Saginaw Bay.

The Dow Chemical Company is located in Midland on the Tittabawassee River, a tributary of the Saginaw River. All samples collected in 1916 above the Dow Plant did not have the peculiar chemical taste, whereas all those below the plant had a very pronounced taste. It was then thought that the wastes from the chlorobenzol plants, where the Dow Company manufactured di-chloro-

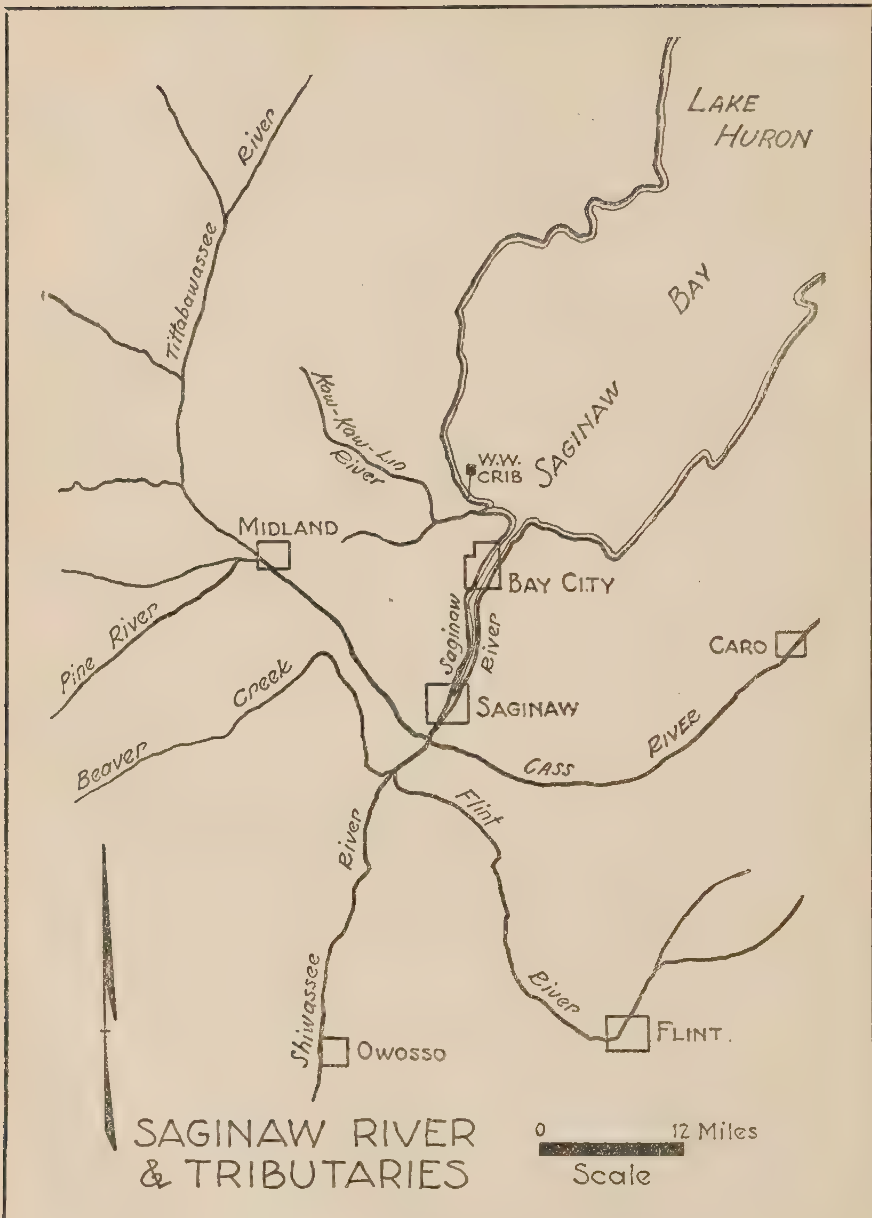
[1] Chief Chemist, Water Department, Bay City, Michigan.

benzol in large quantities for war purposes, were responsible for these tastes and the killing of fish. Owing to war time conditions it was impossible immediately to stop the Dow Company from dumping that waste. However, since 1916, the Dow Chemical Company has been burning all the waste products from the chlorobenzol plants, and still the tastes persisted in the city water during the fall of the succeeding years, although the complaints from the fishermen decreased.

During the fall of the year a great deal of waste from the sugar plants along the Saginaw River and its tributaries is discharged into the river. These wastes are highly alkaline in reaction and rich in organic matter. As a result the dissolved oxygen is greatly depleted in the river during the sugar campaigns. Since these phenol-like tastes periodically recur during the sugar campaigns, the sugar factories were greatly suspected in being partially responsible for these tastes.

In 1920, the people of Bay City voted for a new water works including a filtration plant and new intake. The new intake pipe extends 4200 feet out in the Bay due north. The filtration plant was put into operation in June, 1925. With the exception of occasional musty tastes during September, the filter effluent was good. However, this did not last very long, for on November 4, 1925, chlorophenol-like tastes appeared in the chlorinated water. These tastes lasted for four days. The people went up in arms, and naturally blamed the chemicals used in filtration, as the cause of these tastes. Indignation ran high. Consumers of water called up the office quite provoked, and told us that we had some "nerve" in feeding them with carbolic acid, medicine, or chlorine. To establish definitely the sources of contamination it became necessary to collect samples of water, not only from the Saginaw River and Bay, but also from its tributaries.

As these tastes occurred several weeks after the sugar campaigns had started, I commenced to investigate the wastes from the various sugar plants. We collected samples of Steffen's waste, battery water waste, wash water waste, etc. and after combining these wastes and diluting them I chlorinated the same, producing a residual chlorine of 0.2 p.p.m. which is the amount present in our water when it leaves the high service pumps. I have tried chlorination of the mixed wastes before filtration and after filtration, and have not succeeded in producing a taste similar to the one we were getting in the chlorinated water.



LAKE HURON
SAGINAW BAY
Tittabawassee River
Kaw-Kaw-Lin River
W.W. CRIB
MIDLAND
BAY CITY
Pine River
Saginaw River
CARO
Beaver Creek
SAGINAW
CASS RIVER
Flint River
Shiwassee River
OWOSSO
FLINT.
SAGINAW RIVER & TRIBUTARIES
0 12 Miles
Scale

Fig. 1.

Convinced that the wastes from the sugar plants were not directly responsible for these tastes, I directed my attention to different sources, and observed that whenever we get a southeast or northeast wind the river water is carried over to our intake. This we detect at the plant by a sudden rise in alkalinity and an increase in oxygen consumed. The chlorophenol-like tastes invariably make their appearance after such winds. The coincidence of the tastes with the change in the direction of the wind, satisfied me that these tastes are caused by some chemical in solution in the river water.

Inasmuch as the Dow Chemical Company was dumping chlorobenzol wastes into the Tittabawassee in 1916, we got busy and started to investigate conditions along the Tittabawassee River above and below the Dow Chemical Plant. Samples of water above the Dow Chemical Plant did not have these tastes, whereas those below did. I got in touch with the officers of the Dow Chemical Company and explained the situation to them. Owing to the fact that they were burning all wastes from the chlorobenzol plants they could not see how they could be responsible. It was necessary then to find what particular waste from the plant, if any, was responsible for it. Samples of wastes from the different organic plants were collected, diluted and chlorinated. The wastes from the phenol plants, when chlorinated, had a much more pronounced taste, and similar to the one in our city chlorinated water. The officers of the Dow Chemical Company were very courteous, and while they expressed doubts as to their responsibility in the matter, got busy at once and built a separate disposal system for all the wastes from the phenol plants.

After having established the fact by experimentation that wastes of a phenolic origin in great dilution when chlorinated, were responsible for these particular tastes, I extended the investigations to suspicious waste from other plants along the Saginaw River.

On December 5, 1925, after a strong south east wind, the tastes reappeared in the chlorinated filtered water with an exceptional intensity and lasted for ten days. It appeared to me that some one had dumped a large quantity of phenol wastes into the river. Hence, in addition to collecting samples of wastes from all possibly responsible industries, I interviewed some of the officers. Besides the wastes from the Dow Chemical Company in Midland, the wastes of the Consumers Power Company's gas plant at Zilwaukee on the Saginaw River and the E. I. Du Pont de Nemours Company's wood distillation plant showed the presence of phenolic products. From

my interview with the officers of the gas works, I have learned that during the latter part of the months of October and November they ran short in tank cars for their ammonia liquor and unintentionally let the ammonia liquor flow directly into the river. While I am not positive whether these dumpings, in particular during the latter part of November, were entirely responsible for the tastes, they undoubtedly helped to produce the extreme intensity, as this ammonia liquor contains a considerable amount of phenol. We got in touch with the officers of the Consumers Power Company, and they got busy to prevent the wastes from the ammonia still from getting into the stream.

The Dow Chemical Company, to prevent the phenolic wastes from going into the stream, constructed an intercepting sewer for all suspicious wastes from the organic plants. All these wastes are conveyed to a natural pond of immense size and about three quarters of a mile away from the river. Leaving out the factors of percolation and evaporation, it will take over two years for this pond to overflow. If it ever overflows, it will reach another natural pond of such size that it will take about ten years before it will ever overflow. The possibilities are that the second basin will never be used, as evaporation and percolation through the sandy soil will take care of all these wastes. The Consumers Power Company at Zilwaukee built a settling basin into which all the ammonia still wastes are discharged. From this basin, after the lime settles out, the fluid is pumped to the quenching tank and is used for quenching coke. While writing this paper, the E. I. Du Pont de Nemours Company has done nothing to stop their wastes from going into the stream, and as long as any phenolic waste is being dumped into the stream these tastes may reappear.

Performing experiments at the laboratory on the different wastes, I have noticed that all samples collected below the Dow Chemical Plant had a distinct chlorophenol taste before chlorination, whereas the wastes from the gas works and E. I. Du Pont de Nemours Company required chlorination. However, after some research I have discovered that the wastes from the Dow Plants carried a considerable amount of free chlorine in solution, and this chlorine in combination with the phenol wastes produced the taste. In the wastes from the gas works and E. I. Du Pont de Nemours I have been able to detect the tastes after chlorination in dilutions as high as one in two millions.

The reason why these tastes make their appearance during the latter part of the fall may possibly be attributed to the lower temperature and excessive organic polution from sugar plants. During the summer a vigorous bacterial action goes on in the Saginaw River, and probably these bacteria also decompose the phenolic wastes. On the other hand, late in the fall when the temperature of the water is close to zero, and dissolved oxygen is reduced by the sugar wastes, bacterial action is greatly reduced and the decomposition of phenolic wastes is lessened.

This paper would not be complete without expressing my appreciation for the assistance offered in this work by W. E. Baumgardner, City Manager, J. Crampton, Supt. of Water Works and B. B. Savage, Assistant Chemist.

Jesse H. Purdy

Died February 16, 1926

J. H. Purdy, Dean of water works managers and operators and one of the twelve honorary members of the American Water Works Association, passed away in the seventy-seventh year of his age at the St. Francis Hospital, Pittsburgh, Pa., after an illness of some weeks.

For forty-two years Mr. Purdy had been associated with the water works business and at the time of his death was Senior Vice President of the American Water Works & Electric Co., Inc. Perhaps no one man was more widely known or highly respected among operators of water works properties than Mr. Purdy. Though not an engineer by training his knowledge of operation and construction of water works plants was profound, a fact to which many well constructed and efficient operating properties throughout the country will always bear witness.

Mr. Purdy's connection with the water works business began in 1884, when he was a councilman in the City of Connellsville Pa. At this time a group of business men headed by Mr. W. S. Kuhn, approached the City Council for permission to build a water works plant in that city. Mr. Kuhn was so impressed with Mr. Purdy's abilities that he persuaded him to resign from his position on the Council and take over the active construction of the new water company.

This marked the beginning of Mr. Purdy's connection with the water works industry and the American Water Works & Guarantee Co., the predecessor of the American Water Works & Electric Co., Inc., which companies he served for almost half a century. After the completion of the Connellsville plant, Mr. Purdy obtained the franchises for and supervised the construction of numerous other water companies. For thirty years he was thus actively engaged. The water works plants at Huntington, W. Va.; East St. Louis, Ill.; Kokomo, Ind., and many others will always be tributes to Mr. Purdy's skill and foresight.

When Mr. Purdy became connected with the water works business, operating methods were primitive considered in the light of modern conditions. Always among the first to adopt improvements and refinements in service, Mr. Purdy, during his many years of active service, was active in the development of filtration, chlorination, softening and other processes, which have brought comfort and health into the homes of millions.

Mr. Purdy installed filtration plants at Chattanooga, Tenn., and Little Rock, Ark., prior to 1890, these being two of the earliest successful filtration systems constructed in the United States.

Successful as a business man and a leader in his field, it is another side of Mr. Purdy's character that will be remembered by his friends and associates. Kind and helpful, he always gave of himself. He had the rare gift of bringing harmony and team work to any organization with which he was connected. Mr. Purdy exercised a tremendous influence for good on the lives of his associates—especially the younger men. No one came into contact with him without feeling better for it and there was no conscious effort on his part toward this end.

Besides being an honorary member of the American Water Works Association, which he joined in 1896, Mr. Purdy was one of the founders and a past President of the Pennsylvania Water Works Association. He was associated with other prominent business men in founding Kingsley House, one of the largest welfare organizations in the City of Pittsburgh.

Mr. Purdy leaves behind him to his many friends, a memory of an upright man, who did right, and loved his fellows. There can be no better memorial.

H. Hobart Porter,
George W. Biggs, Jr.,
George W. Fuller.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Fourth Annual Report of Ohio Conference on Water Purification, November, 1924. 1925, 99 pp. The miscellaneous topics discussed included relative value of lactose broth and bile for detection of B. coli, number of dilutions required for calculating B. coli content, and employment of superchlorination and dechlorination with sulfur dioxide as means of eliminating certain gas-forming organisms which are resistant to normal doses of chlorine. It was reported that substitution of pebble quicklime for hydrated lime at Columbus and Delaware plants had proven satisfactory and had effected considerable economy in operating costs. **Offensive Tastes in Public Water Supplies Caused by Industrial Wastes.** W. H. DITTOE. Ibid., 7–10. Prevalence of taste and odor due to phenol-containing wastes and progress in prevention of same are reviewed and discussed, and it is pointed out that power of state health departments to enforce remedial measures has been established in Pennsylvania and Ohio. Evaporation of liquid wastes from coke plants by employing them for coke quenching appears to be most satisfactory method of disposal. **Stream Pollution in Ohio.** W. H. DITTOE. Ibid., 10–13. Progress in survey of stream pollution being conducted by State Dept. of Health is reviewed. In discussion it was stated that excess chlorine treatment for eliminating taste due to phenol was found ineffective in laboratory experiments at Cleveland. **Progress of Seal of Safety Campaign.** R. C. SWEENEY. Ibid., 13–17. Progress in program of examining and placarding semi-public water supplies in the State is outlined. At present time percentage figure of satisfactory semi-public supplies within Franklin County, where campaign was inaugurated, has reached 31. Of 685 public highway supplies examined throughout the State 61 are at present satisfactory and probably 80 per cent of remainder may be improved. **Use of Sodium Aluminate as a Coagulant—Discussion.** Ibid., 31–6. J. P. BROWNSTEAD reported that during 4-month period in 1924 when aluminate and alum were employed at Ashland, Ky., cost of coagulants averaged $9 per million gallons and reduction of bacteria was in excess of 90 per cent, compared with cost of $12 per million gallons, and bacterial reduction of 70 per cent with alum and lime during period in 1922 when somewhat similar river conditions prevailed. Results of 2-month experimental period during which aluminate was substituted for the lime ordinarly used with alum at Ironton, where coagulant is applied in primary and secondary basins in ratio of 2 to 1 respectively, are summarized by E. T. EDWARDS as follows: (1) A

trifle higher efficiency was obtained in primary basin, floc settling more rapidly and producing clearer effluent. This resulted in poorer filter efficiency and more algal trouble in the basins, but altering ratio of coagulant added in primary and secondary basins to 1:1 improved filter influent and efficiency. (2) When sodium aluminate below the normal lime application was employed, final effluent contained too great concentration of free carbon dioxide and had tendency to be corrosive. (3) Cost of treatment during period was higher than average of year, but cost of alum and lime would probably have also exceeded yearly average. Bottle experiments conducted by E. E. Smith at Lima indicated that it would not be economical to replace any part of necessary application of alum with sodium aluminate. Use of latter with alum did not increase speed of reaction or produce larger floc particles. C. P. Hoover, in discussing results of laboratory studies at Columbus, stated that addition of commercial sodium aluminate in softening by lime-soda process has same beneficial effect as alum. It is also an aid to softening due to its sodium carbonate and hydroxide content, whereas alum increases non-carbonate hardness and necessitates employment of additional soda ash. It is estimated that commercial sodium aluminate costs from 74 to 135 per cent more than equivalent mixture of alum, soda ash, and lime solutions. **Dry Feed of Coagulants—Discussion.** Ibid., 36–41. P. J. O'Connor reported that considerable trouble had been experienced at Warren with packing of chemicals in hopper of Gauntt type dry feed machine, particularly with lime. Type "P" machine of Pittsburgh Filter and Engineering Co., subsequently installed, had given very satisfactory results, except that at low rates of flow feed was 20–33 per cent high. W. I. Van Arnum stated that Gauntt dry feed machines had given entire satisfaction at Youngstown for application of hydrated lime, soda ash, and ground alum. Dry feed of alum and hydrated lime with machine of Pittsburgh Filter Manufacturing Co., had been found satisfactory at Ravenna, according to E. C. Lindsey. Opinions expressed in discussion indicated that Gauntt type was not as accurate as Pittsburgh and other types when flow of water varied appreciably. **Water Purification at East Liverpool, O.** Daniel H. Rupp. Ibid., 47–59. History of supply is briefly reviewed. Present system includes intake in Ohio River, grit chamber, 2 coagulation basins, 61-m.g. gravity concrete rapid sand filters, and pedestal type chlorinator. Tabulations of bacteriological data on operation of plant during 1923 are given. Coagulation removes 81–87 per cent of raw water bacteria; filtration 77–84 per cent of bacteria applied; and chlorination 94–97 per cent of bacteria surviving filtration. Final effluent after chlorination complies with proposed standards of U. S. P. H. S., but filter effluent before chlorination exceeded standard of 2 B. coli per 100 cc. during 5 months of year. Raw water is only slightly alkaline on average owing to acid sulfates discharged into river above intake. During one month incrustants averaged 188 p.p.m. Lime is regularly applied to correct corrosiveness of water, average pH being increased from 5.7 to 7.2. River water contains average of 4 p.p.m. of soluble iron and there is probably several times that amount of soluble alumina. This explains the comparatively small amount of coagulant required—0.7 to 1.5 g.p.g. Efficacy of purification of the supply is strikingly demonstrated in typhoid death rate, which was 75.8 per 100,000 during 4-year

period prior to adoption of filtration up to and including 1918, 38.1 during 4-year period following installation, up to and including 1922, when only indifferent part-time analytical supervision practiced, and 4.4 for past 2 years under full-time technical control. Considerable difficulty has been experienced with regard to tastes due to pollution of supply by phenol wastes. Study of the conditions indicates that tastes complained of are phenol tastes and not chlorophenol tastes as result of chlorination. Phenols in excess of 0.1 p.p.m. as determined with Folin-Denis reagent after distillation invariably results in complaints from consumers. Taste appears to be independent of residual chlorine content, which varies inversely with the organic content, being less when efficiency of coagulation decreases. Distinct removal of phenols and substances reacting with the Folin-Denis reagent is effected by purification process as a whole. Phenolic substances removed are not in suspension, and agency effecting removal is believed to be coagulation. When filter sand was cleaned in 1923 to remove incrustation, material removed was found to contain large proportion of phenolic substances, 100 gms. of incrusted sand yielding 15 mgm. of phenol on acidification with sulfuric acid and distillation. Test for tannins on this material, using ferric chloride, was negative. Chlorine treatment does not effect any removal of phenols, phenol content of filtered and of disinfected water being practically identical. Laboratory studies carried out to determine effect of various methods of treatment on phenol content are summarized as follows: (1) Treatment with sodium hypochlorite did not reduce phenol content of solution of chlorophenol containing equivalent of 1 p.p.m. of phenol. (2) Distilled water containing 1 p.p.m. of phenol showed same content of phenol after long standing. (3) Addition of 60 p.p.m. potassium permanganate to distilled water containing 1 p.p.m. of phenol did not alter phenol concentration, but 250 p.p.m. destroyed all phenol present. (4) Phenol content of distilled water was reduced from 1 to 0.5 p.p.m. by treatment with mangan-permutit. (5) Treatment with hydrochloric acid and potassium chlorate did not alter phenol content of distilled water. (6) Ohio River water containing 0.4 p.p.m. when treated with 3 g.p.g. of alum and sodium hydroxide showed after long standing reduction of phenol to 0.1 p.p.m. (7) Tannins distil over more slowly than phenols and are probably oxidized more readily in river water than phenol. (8) Original solution must contain as high as 20 p.p.m. of tannin in order for distillate to give color with Folin-Denis reagent equivalent to 1 p.p.m. of phenol. (9) Iron does not interfere with phenol determination unless present in concentration of 15 p.p.m., and such interference may be avoided by distillation of sample. (10) Phenol appears to undergo oxidation on long contact with river water; therefore proximity to source of pollution is factor in taste production. **Experiences in the Operation of the New Municipal Water Softening Plant at Newark, Ohio.** C. T. Kaiser. Ibid., 60–4. New 6½ m.g. softening and purification plant treating Licking River water is described and data on operation given. Plant consists of mixing chambers, Dorr clarifier, settling basins, rapid sand filters and chlorinator. Split chemical treatment is employed, an average of 9 gr. of lime, 1.5 of soda ash and 1 of alum per gal. being applied to one-third of raw water flow, which after 20 minutes retention is mixed with remaining two-thirds. Hardness is reduced from average of 275 to average of 85 p.p.m.

When incrustant hardness is less than 40 p.p.m. use of soda ash is dispensed with. An average removal of 98.5 per cent of the suspended solids is effected by the Dorr clarifier. Carbonation is carried out by means of carbon dioxide applied through diffusers in outlet of settling basins. Use of scrubbed flue gas from hand-fired boilers for this purpose was found to give rise to chlorophenol tastes after chlorination and coke furnace has since been installed for generation of carbon dioxide, 100 lbs. of coke being required per million gals. The gas applied contains an average of 5 per cent carbon dioxide, while that emerging as bubbles from carbonation chamber contains 0.5 per cent. Process is controlled by hourly tests of phenolphthalein alkalinity, a concentration of approximately 1 p.p.m. of carbon dioxide being maintained in water applied to filters. If free carbon dioxide exceeds 2 p.p.m. an increase in total alkalinity of filtered water occurs, undoubtedly due to resolution of mat on filters. After 6 months operation no change in filter sand can be detected. In discussion, Oklahoma experiences were cited to show that phenols may also be present in flue gas of mechanically stoked boilers, but that introduction of chlorine in considerable amount into flue gas tends to eliminate taste producing constituents. Use of kerosene oil burners for generation of carbon dioxide was favorably commented upon. C. E. Trowbridge stated that at South Pittsburgh, Pa., raw Monongahela River water is first treated at river pumping station with portion of the soda ash to neutralize acidity and thus protect pumps and piping. A portion of the raw water so treated is by-passed into remainder after latter has been softened and settled and before whole passes to filters, advantage thus being taken of large amount of carbon dioxide liberated by soda ash treatment to effect recarbonation. This practice places no undue bacterial burden on filtration process as river water is practically sterile due to the acidity. **The New Water Purification Plant at Toronto, Ohio, Employing Double Coagulation of Ohio River Water.** Daniel H. Rupp. Ibid., 65–7. History of water supply of Toronto is outlined and new plant consisting of mixing chamber, coagulation basins, gravity rapid sand filters, and chlorinator described. Double coagulation is employed at all times, it having been found that best results with least application of chemicals can be obtained thereby. Amount of alum used has averaged 3 g.p.g., in approximate ratio of 2:1 to first and second basin respectively, and lime employed has averaged 2 g.p.g. With exception of first month of operation filtered water before chlorination has met requirement of original standard of U. S. P. H. S. (2 B. coli per 100 cc.) and after disinfection with approximately 0.2 p.p.m. of chlorine, giving residual of 0.1 to 0.15 p.p.m. in tap water, final effluent has easily conformed to revised standard (1 B. coli per 100 cc.). **The Cincinnati Water Works System.** Clarence Bahlman. Ibid., 68–74. Water supply history is outlined and existing system described in detail. Present purification plant consists of settling reservoirs, coagulation basins, and 28 4-m.g.d. rapid sand filters operated of rate of 123 m.g. per acre per day. Power for operation of plant is derived from hydro-electric units installed on pipelines conveying water from settling basins to purification plant, available head being approximately 27 feet. Settling reservoirs remove an average of 70 per cent of bacteria and turbidity present in raw Ohio River water and coagulation basins about 20 per cent. Average B. coli content of river water during past 17 years

has ranged from 1700 to 3400 per 100 cc. Coagulation is effected with lime and iron sulfate. Quicklime is purchased in lump form and is slaked with filtered water at temperature of 140°F., when boiler plant is in operation. During period May–September inclusive, when cold water is employed, extraction is not so complete, but loss is immaterial in comparison with cost of operating boiler plant. Considerable difficulty has been experienced due to incrustation of lime solution pipeline, which is 900 ft. in length. Cost of operation during 1923 was equivalent to $6.76 per m.g. delivered into service, of which $2.44 was expended on chemicals. There are now over 800 miles of water mains and supply is practically 100 per cent metered. Boiler feed water employed consists of mixture of 85 per cent condensate, freed from oil by treatment with alum and caustic soda followed by sand filtration, and 15 per cent permutit-softened water. **An Investigation of Variations in Bacterial Quality of Cincinnati Water Supply.** Clarence Bahlman. Ibid., 75–84. Considerable data derived from bacteriological study of water supplied to consumers in Cincinnati with particular reference to chlorine applied and to multiplication of bacteria during distribution, is given. Chlorine dose at present employed varies from 0.18 to 0.27 p.p.m., former being applied during winter months and latter during periods of maximum water temperature. During former season residual chlorine content of tap water varies from 0.01 to 0.04 p.p.m. but during summer and autumn free chlorine in water delivered is practically nil and during this period highest B. coli content is recorded. An increase in colon and other bacteria, particularly during summer months, was found to occur even in the suburban distribution system on which there is no open reservoir. The higher colon content recorded in water from downtown taps than from purification plant effluent was shown to be due to comparatively high B. coli content of water in the pure water reservoir which is exposed to falling leaves and atmospheric dust. Since contamination with human wastes is most improbable, little sanitary significance is attached to increased number of bacteria in reservoir water. The ultimate tap water conforms to proposed standard of U. S. P. H. S. **Spore-Bearing Gas-Formers in the Ohio River at Cincinnati.** Henry Sohn. Ibid., 85–9. Of 99 samples of Ohio River water examined for spore-bearing gas-formers during period March–October 1924, 21 were found to contain such organisms. Of these unpurified cultures 18 were capable of growing aërobically and 16 grew anaërobically. Only 6 of the 21 positive mixed cultures survived plating and purifying processes and proved capable of fermenting lactose. All 6 were spore-bearers and 4 of them grew aërobically. Remaining 15 positive cultures were apparently due to symbiotic growth of spore-bearing types. Rate of gas formation by spore-bearing types encountered was too slow to cause serious interference with gas production by colon group organisms. During same period 85 per cent of routine presumptive positive tests on Ohio River water confirmed when subjected to usual confirmatory tests for B. coli.—*R. E. Thompson.*

Decision of Court in Patent Case. A decision in the suit of the Electro Bleaching Gas Company and Wallace & Tiernan Company, Inc., against Paradon Engineering Company, in the United States District Court of New York, has been rendered in favor of the plaintiffs. The court held that the

Paradon Chlorinator was an infringement of the Ornstein patent on the solution feed process for the chlorination of water and sewage.—*A. W. Blohm.*

Powdered Coal at Water Plant Proves Saving. Newspaper Item. A coal crusher placed directly in front of boiler reduces coal to powder as it is needed to feed fires. The cost of installing the machine at Des Moines municipal water plant was about $2,500 and the saving from its use is estimated at approximately $7,500 per year. The coal enters the furnace in a spray much as though it were oil being sprayed into the firebox. As it travels through the furnace, the coal is gasified and more air is admittted to secure complete combustion. —*A. W. Blohm.*

Water Supply and Purification. Amer. Jour. Pub. Health, **15**: 4, 314, April, 1925. Progress report of Committee on Water Supply and Purification calls attention to the following: injunction granted by Supreme Court of Pennsylvania, restricting discharge of acid mine drainage into water supply; application of iodine salt to Rochester, N. Y. Water Supply; purification programs of different cities; studies of filter media for rapid sand plants; water softening; improved physical qualities and aëration.—*A. W. Blohm.*

Boiler Corrosion and the Treatment of Boiler Feed Water. A. Winstanley. Water & Water Eng., **26**: 65, February 20, 1924. *Pitting:* (a) Action of salts. Sulphur, liberated by decomposition of calcium sulphide formed by heating calcium sulphate with carbon, produces local corrosion. The carbon may be present in the steel or may be produced from a drop of oil deposit. (*b*) Action of gases. Two theories concerning action of oxygen. (*c*) Action of oil. Animal or vegetable oils are readily split up by heating into glycerine and free acid, latter of which attacks boiler plates producing black, greasy compound. Mineral oils are not usually decomposed to acids, but may cause injury by settling on plates and, by causing local higher temperature, promoting galvanic action. (*d*) Galvanic Action. The two important points to be considered are: (1) Possible potential differences; (2) Factors influencing conductivity of the water. To repress galvanic action, apart from introduction of zinc slabs, water should be de-aërated and treated to reduce salt concentration; purer steel should be used; thick and hard scale should be avoided by water treatment and by frequent cleaning; (*e*) Lime Soda Process and Pitting. In 45 boilers which showed pitting, feed water was treated by this process. In 6 cases the feed water contained more than 10 grains per gallon of sodium salts naturally. In all cases hardness less than 6 degrees. Experiments were made to ascertain effects of concentrated sodium sulphate solutions on new boiler steel by suspending test pieces below water level in Lancashire boilers, using water previously treated by lime soda process. Of 10 samples, kept in boilers from 6 to 10 months, pittings were visible to naked eye on 4, under hand lens on 4 more, and under microscope on remaining two. Tests did not indicate much embrittlement, or reduction in strength. *Grooving.* Is usually most pronounced on upper side of furnace tube at furnace end. Appears to be essentially mechanical process, although possibly influenced by composition of water. More cases have been noticed where distance between rivets attach-

ing furnace tubes to end plates and inner rivets of gusset stays is relatively small. It also appears to be more prevalent in boilers having either thick or hard scale. *Treatment of Boiler Feed Water.* Point is emphasised that insufficient attention is paid to matter remaining in solution in boilers. Water with low degree of hardness appears to be usual requirement, and lime soda process the usual treatment. Analyses given show that after normal periods of running, 5 to 7 weeks, total matter in solution varied from 1452 to 2981 grains per gallon, mainly sodium sulphate and sodium chloride. Not only is additional heat required to evaporate such concentrated solutions, but temperature of water exceeds that of steam with result that foaming occurs and particles of salt are often swept into steam pipes and engines. It is recommended that concentration of boiler water be determined at intervals and never allowed to exceed 0.4 pound per gallon. For matter precipitated in boiler, maximum of ¼ pound per square foot of interior surface is suggested for incrustant salts and double this for sludge, or non-scale-forming material.—*Geo. C. Bunker.*

Tansa Completion Works. Water & Water Eng., **26**: 97, March 20, 1924. Description of fabrication, transportation, and laying of steel pipe lines 55 miles long, from Tansa Lake to city of Bombay, India. Two parallel pipelines, each 72 inches in diameter, are being laid from Tansa to Powai, and three lines from that point on, two of them, each 75 inches in diameter, to Bombay direct, and the third, 60 inches in diameter, to Ghatkoper, there to connect with two existing 48 inch Tansa mains. These lines will convey at first 90 million gallons per day, which can be increased to 160 million gallons without further alteration. The steel plates, ⅜ inch thick, 7 feet 4½ inches wide, and from about 15 to 20 feet long, according to the 3 sizes of pipes required, were drilled for rivets, planed to a bevel suitable for caulking, and scarfed at corners in England. They were then shipped to India for fabrication. The specials were fabricated in England. With a view to reducing field riveting to a minimum, very careful and exhaustive tests of pipe were made in England. These demonstrated that hydraulic riveting in the shop is infinitely preferable to pneumatic riveting in the field. Twenty-four hydraulic riveting machines, each weighing 8 tons and capable of exerting a squeeze of 60 tons on each rivet, are used in the shop in India, reducing the field riveting to one-twelfth of the whole. The pipes leave the shops in 57-foot lengths, fully riveted and caulked. The interior surface is covered with bituminous solution by pneumatic sprayers. Steam driven air compressors are used for riveting and caulking field joints. Painting of outside of pipe lines will not be done for several months so as to allow weather to remove mill scale before hand painting. At intervals of about 4 miles is provided an elaborate system of valves and cross-connection which will rest on solid blocks of concrete to prevent any movement due to rise in pressure when closing valves. Air valves are provided at high spots and scour valves at low spots. Expansion joint is provided every 1000 feet in order to relieve circumferential field joints from temperature stresses. It has been found by actual experience that each 1000 feet of pipe, when empty, has moved in and out of the expansion joint as much as 6½ inches on a warm day, and it is calculated that movement may be as much as 8½ inches in very

hot weather. Curves are turned by means of special taper pieces hydraulically riveted to ends of 57-foot lengths in the shop. It is expected that work will be finished before end of 1925. Illus.—*Geo. C. Bunker.*

The Influence of Hydrogen Ion Concentration on the Dose of Alum and the Mechanism of the Action of Alum in the Clarification of Natural Waters. Nani Lal Banerji. Water & Water Eng., **26**: 104, March 20, 1924. (Abstract from the Indian Journal of Medical Research, January, 1924.) River Hooghly is the source of water supply for Calcutta and other suburban municipalities. Every year during monsoon, middle to end of June, it assumes reddish appearance from iron oxide silt from red soil, brought down by one or other of tributaries. The main bulk of silt consists of extremely fine particles which interfere with sedimentation and require usually high dose of alum for clarification. Last year fineness of particles was such that clarification was not complete and Calcutta filtered water, instead of being clear and transparent as usual, was decidedly opalescent. This caused a certain amount of agitation among public as to purity of water supply. Later on, lime was used with alumino-ferric to hasten sedimentation. Author's investigations led him to conclude that addition of lime was not justified either on theoretical grounds, or by results in practice. Four conclusions are drawn by the author from his experiments namely: (1) Other factors remaining constant, viz., suspended matter, size of particles, and concentration of electrolytes, optimum dose of alum increases as pH increases and decreases as pH decreases. (2) Total hardness plays important rôle in regulating dose. (3) Mechanism of action of aluminum sulphate is divided into two portions due respectively to (1) unhydrolysed aluminium sulphate, and (2) hydrolysed aluminium sulphate, which again is made up of two components: (*a*) sulphuric acid, (*b*) aluminium hydroxide. Positive aluminium ion from unhydrolysed portion is most potent factor in clarification. Next comes hydrogen ion from sulphuric acid. Last and least is $Al(OH)_3$ solution. (4) Dose of alum can be decreased by preliminary addition of cheap acid, such as sulphuric. During monsoon, as much as 1 ton of alumino-ferric is used daily by Calcutta. In view of facts revealed by this investigation, consumption of alum can be lessened by using acidulated water instead of ordinary water in dissolving tank. Addition of acid is limited by pH of water. If original pH be not high, we cannot acidify water too much, because it may affect taste and injure machinery. Dose of alum and acid can be so regulated that resultant pH shall not greatly differ from absolute neutral point, 7.0, in which case taste and machinery will remain unaffected.—*Geo. C. Bunker.*

Water Softening by Means of Doucil. T. P. Hilditch and H. J. Wheaton. Water & Water Eng. **26**: 109, March 20, 1924. Description of comparatively new base-exchange material manufactured by J. Crosfield & Sons, of Warrington, England, under name of "doucil." It is a complex silicate, containing replaceable combined soda, in form of dried gel and is marketed on a 50 per cent moisture basis, which means that 1 ton will soften to "zero hardness" about 22,000 gallons of water. For treating this volume of water doucil bed 6 feet deep in cylindrical shell about 3 feet 6 inches in diameter by 8 feet high

would be suitable; with brine tank of about 360 gals. A 6-foot bed will soften 15 to 20 per cent more water than two 3-foot beds of same area. The preferred size of grain is now from $\frac{1}{8}$ to $\frac{1}{20}$ inch; resistance offered by 6-foot bed of this size is only about 1 pound per square inch at normal rates of flow. (Cf. this JOURNAL **12**: 2, 255–6.)—*Geo. C. Bunker.*

A Unique Equilibrium Ball Valve. Water & Water Eng., **26**: 111, March 20, 1924. Note concerning two very large 25-inch diameter bronze valves constructed for Talybont waterworks scheme of Newport Corporation by Glenfield & Kennedy of Kilmarnock. Weight of each valve is approximately 9912 pounds; working pressure is 214 feet but shop tests of 400 feet have been made. Illus.—*Geo C. Bunker.*

Water Purification for Industrial Purposes. J. P. O'CALLAGHAN. Water & Water Eng., **26**: 112, March 20, 1924. Description is first given of 4 million Imp. gallons per day rapid sand filter plant at Becton works of Gas Light & Coke Co. Raw water is taken from Thames River. Advantages and economies of softening water for boilers by lime-soda and permutit, or zeolite, processes are discussed. In many respects zeolite softening offers great attractions; but this treatment alone is not usually economical where hardness exceeds 40 grains per gallon: in such cases a combined lime-soda and zeolite plant can be effectively employed. By a modification of permutit process minute quantities of iron and manganese and all organic matter may be removed. By treating sodium permutit with a manganese salt, manganese permutit is produced, by which all iron and manganese salts are oxidized and precipitated, and at same time, all organic matter and bacteria are also oxidized. Manganese permutit must be periodically regenerated by addition of potassium permanganate. Great success of French silk industry is mostly due to purity of water used. The largest of the French silk houses has installed permutit process to remove about 5 degrees of hardness from water supply.—*Geo. C. Bunker.*

Relation of Boiler House Equipment to Plant Economy. THEODORE MAYNZ. Chem. and Met. Eng., **32**: 17, 851–2, November, 1925. Boiler plants should have earning capacity above interest and investment charges. If power cannot be produced cheaper than it can be purchased, it should be purchased. Boiler plants for 24-hour production should have equipment that is reliable and of high economy. Such plants should have at least three boilers, any two of which will carry the load without excessive ratings. Feed pumps should be in duplicate, draft apparatus so arranged that any unit can be taken out of service for repairs, and ash and coal handling apparatus so arranged that their failure will not put plant out of operation. Boilers should be equipped with stop and non-return valves, soot blowers, flow meters, CO_2 recorders, draft gages, flue temperature recorders, and automatic stokers or pulverized coal equipment. Hand fires have no place in 24-hour plant, even with cheap coal. Equipment must be suitable for conditions under which it is to operate, and must be properly installed. Boiler plants operating 10 or 12 hours a day with low load factor cannot afford any thing but simplest and most inexpensive

apparatus that will perform the work. Hand fires, hand lance flue cleaning, cheap water meter, and simple coal handling are all that will pay dividends unless fuel is extremely high. Operation of average industrial boiler plant is inefficient.—*John R Baylis.*

Stream Pollution—a Symposium. Proc. Am. Soc. Civ. Eng., 51: 9, 1809–55, November 1925. **A Review of the Work of the United States Public Health Service in Investigations of Stream Pollution.** W. H. Frost. In March, 1901, Congress provided for erection of laboratory by U. S. Public Health Service for investigation of contagious and infectious diseases and matters pertaining to public health, and in same year Division of Scientific Research was organized. In 1910, first systematic investigation of status and effect of sewage pollution in any large area was begun on cities in Great Lakes region. Duties of Public Health Service were extended in 1912 to include diseases of man and conditions influencing propagation and spread thereof, including sanitation, sewage, and pollution of navigable streams and lakes of United States. Field laboratories were established for first time in 1913. Comprised amongst work undertaken have been studies of bio-chemistry of sewage and industrial wastes, studies to devise better methods for treatment of various important industrial wastes, study of pollution and natural purification of Potomac and Ohio Rivers, survey of municipal sewage disposal plants in various parts of the U. S., and collective study of municipal water purification plants as operated on Ohio River and elsewhere. **The Rate of Deoxygenation of Polluted Waters.** Emery J. Theriault. The Phelps formula holds with reasonable accuracy when applied to samples recently polluted with organic matter. For periods of incubation of less than 10 days it is possible to refer results obtained under standardized laboratory conditions to actual times of flow and temperatures of stream. Under aërobic conditions, stabilization of organic matter apparently proceeds in two distinct stages. Rate at which polluted water is deoxygenated depends largely on condition of sample with respect to its state of oxidation. Complete solution of problem probably depends on development of methods whereby state of oxidation of a sample may be determined more rapidly. **The Rate of Atmospheric Reaëration of Sewage Polluted Streams.** H. W. Streeter. The reaëration of flowing streams proceeds substantially in accordance with physical laws which have already been described. Rate at any time is controlled mainly by temperature, turbulence and oxygen saturation deficit of stream. An empirical method of measuring rates of reaëration is described. By proper combination of predetermined rates of reoxygenation and of reaction a reasonably accurate calculation may be made of resultant progressive changes in dissolved oxygen content of a stream under any given or assumed condition of flow, temperature, and initial degree of pollution. **Quantitative Studies of Bacterial Pollution and Natural Purification in the Ohio and the Illinois Rivers.** J. K. Hoskins. Observations of pollution of these rivers indicate that number of bacteria contributed per capita by sewered populations of various cities are reasonably constant. Method is suggested for estimating maximum concentration of B. coli in streams of known volume of flow that may be expected from known sewered populations.—*John R. Baylis.*

Natural Water Corrosion and H-Ion Concentration. John R. Baylis. Chem. and Met. Eng., 32: 17, 874–5, November, 1925. Experiments do not confirm the work of several authors that over 3.0 parts per million of soluble iron will exist in water free from dissolved oxygen when pH is between 8 and 9. Solubility equilibrium of ferrous carbonate largely determines whether or not water will stain after passing through iron pipes. Alkalinity and pH affect this equilibrium. Solution inside an active tubercle and pit maintains pH close to 6.0, regardless of that of outside water. Tubercles overlying pits tend to form impervious layer of crystalline iron oxide near surface of tubercle. This eventually stops corrosion unless impervious layer becomes broken. Alkaline waters heal such breaks more readily than neutral or slightly acid waters.—*Frank Hannan.*

Utilizable Capacity of Steel Members of Structures. Henry S. Prichard. Proc. Am. Soc. Civ. Eng. 51: 9, 1735–92, November, 1925. Fundamental factors on which utilizable capacity of steel members of structures depends and methods of determining such capacities are given. Utilizable capacity of any steel member is measured by greatest load which can be applied during life time of structure without causing failure, ruin, or objectionable deformation.—*John R. Baylis.*

Queen Mary's Reservoir. Anon. Public Works, 56: 320, 1925. Reservoir covers 723 acres, has capacity of 6,000 million gallons, average depth of 38 feet, and artificial embankment lined with concrete slabs.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Hetch Hetchy Bay Crossing Division. Anon. Public Works, 56: 371–74, 1925. Construction features of twenty mile pipe line for San Francisco Bay Crossing Division of Hetch Hetchy water supply project are given. Line consists of 60-inch riveted steel pipe laid partly on a trestle and on a 36 span steel bridge, and of 42 inch submarine type flexible-joint cast iron pipe under water ways.—*C. C. Ruchhoft.*

Denver's Concrete Sand Trap. Ivan E. Houk. Public Works, 56: 378, 1925. Trap is concrete box, 2.5 feet deep and 18 feet wide, set transversely in bottom of Denver Water Company's High Line Canal and located about a mile below canal intake on South Platte river and about a quarter mile above the 300 million gallon Platte Canyon reservoir. Trap is provided with gates on one side so that sand which settles in it may be sluiced back into river.—*C. C. Ruchhoft.*

Hydrogen Ion Concentration and pH. Linn H. Enslow. Public Works, 56: 361–66, 1925. General description of significance of pH and its rôle in practical filter plant operation.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Water Works Plans for New Jersey Municipalities. Anon. Public Works, 56: 374–75, 1925. Changes in rules and regulations of State Department of Health governing preparation and submission of plans for water supply and purification works.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Customer Ownership Plan for Water Companies. PHILIP B. NILES. Engr. & Contr., 64: 106–9, 1925. Advertising and sales methods used by Terre Haute Water Works Corporation to sell its stock to its consumers are described.—*C. C. Ruchhoft.*

Simple Solution of Hydraulic Problems. ROBERT W. ANGUS. Engr. & Contr., 64: 81–5, 1925. Practical methods are given for solving loss of head in pipe and other water works problems.—*C. C. Ruchhoft.*

Town Solves Fire Flow Problem with Standpipe. HARRY F. HUY. Engr. & Contr. 64: 94–6, 1925. Village of La Salle, New York, obtains its supply from adjoining city of Niagara Falls. During times of fire, residual pressure in mains of village sometimes dropped to 10 pounds and village received low insurance rating. To remedy this standpipe 35 feet in diameter and 100 feet high was constructed in central situation.—*C. C. Ruchhoft.*

Denver's New Water Supply Conduit. Anon. Public Works, 56: 271–5, 1925. Construction of 66–inch pre-cast reinforced concrete pipeline six miles long, connecting clear water reservoir at Marston Lake filter plant with city, is described. At Bear Creek crossing, $\frac{7}{16}$-inch steel pipes were laid on two rows of timber piles and encased in concrete.—*C. C. Ruchhoft.*

Reservoir and Pipeline Tunnel for Calumet City, Illinois. ERNEST A. CLARK. Engr. & Contr., 63: 1041–6, 1925. Construction of circular reinforced concrete reservoir 180 feet in diameter and 13 feet high with capacity of 2,000,000 gallons and of 7 by 7 foot water pipe siphon tunnel under Calumet River are described.—*C. C. Ruchhoft.*

Constructing Reinforced Concrete Reservoir. Anon. Public Works, 56: 213–4, 1925. Construction features for Eastern Hills reservoir at Cincinnati are described. Reservoir is 400 feet square by 30 feet deep with a capacity of 35,000,000 gallons.—*C. C. Ruchhoft.*

The Madrid Water Supply. Anon. Engr. & Contr. 64: 103–5, 1925. The history, present installation, and proposed extensions to conduits of Madrid supply are described.—*C. C. Ruchhoft.*

Care of Concrete Reservoirs. R. E. McDONNELL. Munic. & County Eng., 68: 233–35, 1925. It is almost impossible to build large concrete reservoir and not have leakage. Best ways to avoid leakage are:—"(1) A careful study and test of the soil and material used in construction. (2) Design and plans utilizing the best recognized engineering skill with ample factor of safety. (3) Inspection of the most rigid character."—*C. C. Ruchhoft.*

Methods and Policies of Preventing Stream Pollution. H. V. PEDERSON. Munic. & County Eng., 68: 133–35, 1925. Stream pollution situation in Iowa is discussed and conservative policy in prevention of stream pollution is advised.—*C. C. Ruchhoft.*

Review of Water Purification Fundamentals. J. B. MARCELLUS. Munic. & County Eng., 68: 243–45, 1925. General article in which examination of water, bacteria, water treatments, and filtration are discussed in simple language.—*C. C. Ruchhoft.*

A Modern Water Softening and Filtration Plant. Anon. Fire and Water Eng., 78: 399 (1925); Pub. Health Eng. Abst., September 5, 1925, Water Supplies p. 50. The Miami, Florida, supply is derived from 9 wells. It is treated with lime, alum, carbonated and filtered.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Northern New Jersey's Proposed New Water Supply. MORRIS R. SHERRERD. Fire and Water Eng., 78: 403 and 430 (1925); Pub. Health Eng. Abst., September 5, 1925, Water Supplies, p. 50. Plan of development in five steps over a period of 55 yrs. Chimney Rock reservoir, the Raritan, the tributaries of the upper Delaware river, and finally part of the flow of the Delaware itself are considered. Entire yield estimated to be 750 m.g.d. with cost about $86,000,000.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Measures Being Taken to Improve the Water Supply Systems in Porto Rico. OCTAVIO MARCANO. Porto Rico Health Bul., 1, 23–29 (1925); Pub. Health Eng. Abst., September 19, 1925, Water Supplies, p. 54. Supplies of 46 communities serve 25 per cent of the population. Most supplies are derived from polluted surface sources which are turbid at times. San Juan water works of 1899 is now inadequate and is being supplemented by an 8 m.g.d. rapid sand filter plant.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

New Medium for the Differentiation of B. coli in Water Analysis. J. L. PAWAN. Annals of Tropical Med. and Parasitology, 19: 319–326 (1925); Pub. Health Eng. Abst., September 26, 1925, Water Supplies, p. 56. Brief summary of British and American methods is given. Water borne disease in tropics is rare though the population uses a polluted water supply of high coli index figured on the British standard (Lactose plus, Indol plus). This situation may be due to accidental absence of pathogens, the sterilizing effect of the tropical sun or to an improper coli index due to failure to differentiate between fecal and non-fecal forms. After applying various tests, the medium of Koser (*J. Bact.* 9, 59, 1924) is credited with being best. The author considers it much superior to the methyl red and Voges-Proskauer tests.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Treatment of Alkali and Other Waters for Domestic Use. G. A. CUMMINGS. Colorado Agr. Expt. Sta. Rept., p. 40 (1924); Expt. Sta. Rec., 53,185 (1925); Pub. Health Eng. Abst., September 26, 1925, Water Supplies, p. 57. Distillation is the only suitable method.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Filtration of Swimming Baths. ANON. J. Roy San. Inst., 46: 47–52, 1925. Discussion of costs involved. Chloros is recommended as disinfectant.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The "Guta" Automatic Chemical Control Apparatus. E. DEPLANTADE. La Technique Sanitaire, **20**: 106–110, 1925. Control of chemical feed by varying head on orifice connected by tube to solution reservoir. Control of height is accomplished by float connected to orifice tube by cord carried over pulley or by counterpoised vessel containing variable quantity of water. Rate of flow of water supply determines height of liquid in float chamber or counterpoised vessel.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Determination of Minute Amounts of Phenols in Polluted Natural Waters. LOREN R. VORCE. Ind. Eng. Chem., **11**: 751, 1925. Two or three l. of water are freed as well as possible from Ca, Mg, etc., by treatment with NaOH and filtration. H_2O_2 free from compounds with benzene nucleus is added and allowed to stand over night. Resulting solution is concentrated to 200 cc. in strong alkaline condition, made acid by addition of citric acid crystals, and distilled. In distillate, phenol is determined colorimetrically by use of Folin and Denis reagent.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Economical Use of Alum in Mechanical Filters. A. D. STEWART and V. GOVINDA RAJU. Water and Water Eng., **27**: 273–274, 1925. Rapid sand filters operating on clear waters which have had some storage reach maximum efficiency after being fed with coagulated water for one hour; use of alum thereafter can be dispensed with without impairing efficiency. This allows reduction of chemical cost.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Surface Tension as a Factor in the Priming of Steam Boilers. E. B. MILLARD and T. E. MATTSON. Ind. Eng. Chem., **17**: 685–686, 1925. No connection exists between surface tension and priming of boiler waters.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Primary Filtration for Municipal Water Supply. J. A. BERNARD. La Technique Sanitaire. **20**: 25–26, 1925. Details of St. Denis plant. Water is taken from St. Denis river. Settling basin has four compartments, each provided with inlet, discharge channel, 2 copper screens, drain, and opening and closing mechanism. Water enters base of filters and passes upward to service tank and thence to mains.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Algal Growths in Tank Waters. V. GOVINDA RAJU. Water and Water Eng., **27**: 57, 1925. Algae seem to prefer temperature of about 75°F. and die off as reservoirs get low and the water goes above that temperature. They then decompose and give off bad odors. Copper sulphate and lime have not been very effective under Indian conditions. H_2SO_4 in amount necessary to neutralize bicarbonates has been very successful. It is not necessary to add the dose all at once. Most important algae have been (1) Oscillaria; (2) Anabaena, (3) Cylindrospermum, (4) Navicula. A euglena forms thick red coating at times on water. Spirogyra is most important layer form of alga.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Silt Equilibrium. HERBERT CHATLEY. Water and Water Eng., **27**: 95, 1925. Airy says that weights of individual particles vary as 6th power of

velocity of stream carrying them. C. finds that this does not apply to non-turbulent flow. In this case weight varies as the 1.5 power of velocity. Particles settle with long diameter across bottom of stream at right angles to direction of flow.—*Jack J. Hinman, Jr.* (*Courtesy Chem Abst.*)

The Thiem System of Constructing Tubular Wells. Ed. Imbeaux. La Technique Sanitaire. June, 1925. Consists of number of small but deep borings over catchment area. Each well has head works, main tube for catchment, copper suction tube, observation tube discharging at surface level, and collecting conduit. Excavation is limited to shaft boring and ordinary conduit trenches. Found to yield better than few large wells with collecting tunnels. Whole of Leipzig supply collected by Thiem system.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Influence of Forest Land on Runoff. L. W. Collet. La Technique Sanitaire, 20: 167–168, 1925. Comparison of thickly wooded and slightly wooded areas showed runoff from former considerably greater. In dry periods, torrent from wooded land flowed, while that from open land dried up. Grass land is not very absorbent. Upper 18 inches of forest land is permeable. Idea that leaves and vegetable debris retain much water is erroneous.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Condensation of Water in the Ground. J. Versluys. Water en Gas, July 3, 1925, p. 144. Condensation of gases by absorption takes place on surface of solid bodies and is most intense in capillary spaces. Water may condense from soil air even though latter be not saturated. Between adjacent grains drop with concave surface forms and increases in size until equilibrium has been attained. These drops probably do not fuse and flow into the ground water, but probably are available to rootlets of plants, absorption by which of water may disturb the equilibrium and induce further condensation.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Water Supply of the City of Aberdeen. George Mitchell. Water and Water Eng. 27: 56, 1925. Old works 20 miles west of city took water from river Dee; consisted of 12 mg. storage reservoir, ½ acre of slow sand filter, and 18.5 miles of brick aqueduct. Capacity 8.5 m.g.d. Enteric epidemic in 1912 was at first ascribed to the water, though now believed to have been due to milk. New scheme authorized for water supply in 1916 is based on 40 Imp. gals. per day per person for population of 240,000. It consists of screen and intake chamber leading to 60 inch conduit and new 24 mg. concrete storage reservoir. There are 3 new filters of a total area of 1.4 acres arranged to be cleaned by squeegeeing instead of by scraping. Water of Dee is very clear.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Water Softening: the Essential Principles Involved. Anon. Water and Water Eng., 27: 361–362, 1925. Colliery waters are best softened by lime and soda hot process. Zeolites are attacked by acids in these waters and interfered with by the iron and oil.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Short History of the Keighley, England, Water Works. M. Ratcliffe Barnett. Water and Water Eng., 27: 345, 1925. Original supply from wells or springs established in 1816 was superseded in 1891 by slow sand filtration system. Water is treated with Na_2CO_3 before filtration to reduce plumbosolvency and is passed after filtration through beds of polarite. Illustrations of plant.—*Jack J. Hinman, Jr.* (*Courtesy Chem Abst.*)

Water Supply in Holland. F. A. Liefrinck. Water and Water Eng., 27, 356–361, 1925. Oldest public system is that of Amsterdam constructed in 1853. 108 undertakings supply 325 communities; 4.6 million out of 7 million inhabitants are supplied from public supplies. Peculiarities of ground water in sand dunes close to the sea is discussed.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Report of Bureau of Sanitary Engineering, Maryland State Department of Health, 1924. Abel Wolman. 15 pp. Admirable presentation of work of Bureau during 1924, which included investigations in connection with new water supply and sewage disposal undertakings, routine control of existing system, stream pollution studies, oyster pollution investigations, flood control and sanitary surveys. Considerable progress was made in regard to water supply sanitation, the Legislature having granted enabling Acts for bond issues totalling $19,000,000 for water and sewage improvements. Study of effect of water purified by modern methods upon goldfish showed that fish life is not seriously affected by chlorine in doses as high as 3 p.p.m., and that acids, copper sulfate and alum in usual amounts do not detrimentally affect gold fish, minnows and trout. Goldfish mortality in Baltimore was found due to excessive amount of dissolved oxygen in the water. Rapid change in dissolved oxygen content causes great discomfort to fish, high concentrations causing death in very short time. Mortality of goldfish is low at temperatures above 50°, while below this point fish become sluggish, being practically dormant at 40°. Study of treatment of a highly colored deep well water of high silica content showed optimum pH for coagulation of this water to be approximately 8.6, addition of lime prior to coagulation being necessary. Survey of treated water reservoirs in Baltimore disclosed fact that some are exposed to surface pollution of possible human origin, and plans have been made for more careful control and for installation of chlorination apparatus for secondary treatment. Examination of water from 62 individual wells in connection with extension of supply of Salisbury showed water from wells in excess of 100 feet deep to be high in iron and practically devoid of oxygen, that from wells 50–100 feet deep to be low in iron and hardness, and that from under 50 feet to be low in alkalinity and iron but high in chlorine and free carbon dioxide. Water from all wells was corrosive. Depth of 100–150 feet was recommended. Investigations were made during year of stream pollution arising from discharge of wastes from various industries,—tanneries, creameries, canneries, oil refineries, etc. Investigation of action of chenopodium oil upon fish life showed that detrimetal effect was due to toxic nature of the oil and not to loss of dissolved oxygen or to acidity. Concentrations of less than 50 p.p.m. are not fatal to fish unless period of exposure is longer than 3 hours. Data on

pollution of Antietam Creek between Bridgeport and Funkstown and conclusions derived from study of same are given. Typhoid death rate during year was 6.4 and 10.3, inclusive and exclusive of Baltimore respectively.—*R. E. Thompson.*

Purifying Industrial Water. D. H. Killeffer. Ind. Eng. Chem., 15: 915–7, 1923. From chem. Abst. 17: 3393, October 20, 1923. General discussion of character of water from different sources, softening by precipitation and zeolite methods, and uses of treated water in various industries.—*R. E. Thompson.*

Sterilization of Drinking Water With Chlorine. J. Versluys. Arch. Suikerind, 31: 687–96, 1923. From Chem. Abst., 17: 3393, October 20, 1923. Chlorine in doses of 0.75–1, and at times as high as 1.7, grams per cubic meter are employed in purification of river water at Soerabaia, Java, excess being removed with sodium sulfite.—*R. E. Thompson.*

Chicago Menaced by Goiter. Anon. Chicago Dept. of Health, Weekly Bull., 17: No. 34, (new series) 137–44, August 25, 1923. From Chem. Abst. 17: 3393, October 20, 1923. Lake Michigan water contains 0.281–0.681 parts per billion of iodine and it would cost $57,120 per year for sufficient sodium iodide to increase iodine content to $\frac{1}{75}$ grains per gallon. Chocolate tablets containing organic iodide recommended.—*R. E. Thompson.*

Use of Aluminium to Prevent Steel Corrosion. A. V. Farr. Chem. Met. Eng., 29: 1188–9, 1923. From Chem. Abst., 18: 965, April 10, 1924. Process known as calorizing, consisting of alloying surface of steel with aluminium, protects steel against corrosion.—*R. E. Thompson.*

The Hydrogen-Ion Concentration of Different Kinds of Glassware When Sterilized With Buffered and Nonbuffered Solutions. F. W. Fabrian. Mich. Sta. Rept., 1921, 173–8; Expt. Sta. Rec., 48: 204. From Chem. Abst., 17: 3350, October 20, 1923. Data reported from study by R. C. Stull. For nonbuffered solution triple distilled water was used and for buffered solution standard nutrient broth, both being adjusted to pH 7. Determination of pH was made colorimetrically with Clark and Lubs indicators in Cooledge comparator. Tabulated results showed that glassware taken from stock and filled with nonbuffered solution yielded enough alkali during autoclaving to change reaction from pH 7 to 9.8. Amount of alkali yielded by same glass was not sufficient, however, to change reaction of buffered solution during autoclaving. Soft glass yielded more alkali on autoclaving than did hard glass. Treatment of glass with cleaning solution did not prevent solution of alkali on autoclaving, but appeared to destroy or neutralize substances that in some tests interfered with action of indicator.—*R. E. Thompson.*

Steam-Turbine-Driven Centrifugals. V. Dintr. Z. Zuckerind. cechoslov. Rep. 47: 444–7, 1923. From Chem. Abst., 17: 3391, October 20, 1923. Tests were made on experimental model from Breitfield, Danek and Co. Making

certain assumptions as to efficiency of other power devices, it is calculated that mechanical efficiency of belt-driven centrifugals is 72 per cent; electrically driven, 53 per cent; water-driven (water supplied by steam pump) 45 per cent, and water-driven using electrically operated centrifugal pumps, 23 per cent. Steam-turbine-driven macbine has mechanical efficiency of 97 per cent, and because of simplicity of construction it is probably superior to other types.—*R. E. Thompson.*

Chemical Analysis of Water from Caravan Wells in Arabia. GEORGIADES. J. pharm. chim. **27**: 497-502, 1923. From Chem. Abst., **17**: 3393, October 20, 1923. Data on 7 waters of ill-defined origin.—*R. E. Thompson.*

Catalytic Action of Colloids in Corrosion. JOS. K. WOOD. Chem. Met. Eng., **29**: 188-92, 1923. From Chem. Abst. **17**: 3313, October 20, 1923. Discussion of colloidal theory of corrosion proposed by Friend (C. A. **15**: 3013).—*R. E. Thompson.*

The Hydrogen-Ion Concentration of Soils and Natural Waters in Relation to Animal Distribution. W. R. G. ATKINS. Rept. Brit. Assoc. Advancement Sci., 1922, 373. From Chem. Abst., **17**: 3345, October 20, 1923. Close connection exists between distribution of plants and soil reaction, and furthermore many animals (especially insects) are related to specific plants. These facts are correlated, with aid of several examples (mosquito larvae, etc.), to show that direct relation exists between distribution of certain animal life and soil reaction.—*R. E. Thompson.*

Therapy and Prophylaxis in the Control of Goiter. J. WAGNER-JAUREGG. Wiener klin. Wochschr., **36**: 139–42, 1923. From Chem. Abst., **17**: 3371, October 20, 1923. Discussion of recent attempts to control goiter by various means of iodine administration, particularly in Switzerland.—*R. E. Thompson.*

The Therapeutic Use of Iodine in Goiter. N. JAGIC and G. SPENGLER. Wiener klin. Wochschr., **36**: 264–5, 1923. From Chem. Abst., **17**: 3371, October 20, 1923. Favorable clinical results of iodine treatment of goiter and various forms of Basedow's disease reported.—*R. E. Thompson.*

Acid- and Rust-Proof Materials for Chemical Works. REX FURNESS. Chem. Age (London) **9**: 198–200, 1923. From Chem. Abst. **17**: 3391, October 20, 1923. Description of more important acid- and rust-proof materials together with discussion of chemical properties demanded.—*R. E. Thompson.*

Presence of Barium and Strontium in Natural Brines. A. G. FRANCIS. Analyst, **48**: 315–20, 1923. From Chem. Abst., **17**: 3309, October 20, 1923. Barium and strontium sometimes in amounts of 10 p.p.m. each have been detected in English and Scottish brines obtained in boring for oil. Method of analysis consisted in removing iron and aluminium with ammonium hydroxide, precipitating barium as barium sulfate after removal of strontium and calcium as oxalates, conversion of oxalates to oxides by ignition and to nitrates by

treatment with nitric acid, and treatment of anhydrous nitrates with alcohol. Presence of barium and strontium is accounted for as follows: Water charged with carbon dioxide falls upon igneous rocks containing feldspar, hyalophanes and micas and some alkaline earth passes into solution as bicarbonate. Water subsequently percolates through rock or stratum containing zeolites or kindred minerals which retain alkaline earth like permutite filter; then when brine comes in contact with zeolite there is exchange of alkaline earth of sodium.—*R. E. Thompson.*

The Hydrogen-Ion Concentration of Natural Waters and Some Etching Reagents in Relation to Action on Metals. W. R. G. Atkins. Trans. Faraday Soc. (advance proof), 1922. From Chem. Abst., **17**: 3313, October 20, 1923. H-ion concentration of natural waters varies between pH 6 and 8.3 unless more acid as result of oxidation of sulfur. Solutions of ferrous salts become more acid on standing, ferric hydroxide being precipitated. Ferric hydroxide is completely precipitated before ferrous hydroxide as solution is made progressively more alkaline and latter is not completely precipitated at pH 7.1. Thus, trace of acid suffices to attack iron, and hydroxide produced by hydrolysis is oxidized and precipitated, upsetting equilibrium and regenerating the acid.—*R. E. Thompson.*

Corrosion of Non-Ferrous Metals. W. Fraenkel. Z. Metallkunde, **15**: 161–3, 1923; cf. C. A. **17**; 2554. From Chem. Abst. **17**: 3313, October 20, 1923.—*R. E. Thompson.*

Effect of Alkali on Portland Cement. K. Stejk. Wyoming Agr. Expt. Sta. Expt. Circ., **16**: 4 pp., 1922. From Chem. Abst., **17**: 3239, October 10, 1923. Of salts which may be present in alkali, magnesum chloride has greatest disintegrating effect upon concrete, followed by sodium sulfate and magnesium sulfate. Sodium chloride increases and sodium carbonate decreases the harmful effects of sulfates. Sodium chloride when present alone has almost no effect. Mortars containing small quantities of cement disintegrate in less time. Age of cement before it comes in contact with solutions of alkali does not seem to have great effect on rate of disintegration.—*R. E. Thompson.*

The Mechanism of Corrosion. John Johnston. Ind. Eng. Chem., **15**: 904–5, 1923. From Chem. Abst., **17**: 3312, October 20, 1923. In study of corrosion proper emphasis has not been placed on influence of effects at surface of metal. Study of equilibrium in systems at surface of corroding metal and of electrical resistance and capacity of protective films should yield information that would help in understanding of problem.—*R. E. Thompson.*

The Corrosion of Iron in the Presence of Iron Sulfide. Robert Stumper. Compt. rend. **176**: 1316–7, 1923. From Chem. Abst. **17**: 3313, October 20, 1923. Corrosion of iron in tap and chlorinated mineral waters at 17°C., was accelerated 95 and 68 per cent respectively by direct contact with iron sulfide. In 1 per cent sodium chloride direct contact accelerated corrosion 230 per cent and indirect contact by means of iron wire induced strong galvanic action and

increased corrosion 470 per cent. Phenomenon is clearly electrical.—*R. E. Thompson.*

Base Exchange in Ground Water by Silicates as Illustrated in Montana. B. COLEMAN RENICK. U. S. Geol. Survey Water Supply Paper **520-D**: pp. 53–72, December 15, 1924. A study of analyses of water from well s of different depths in certain formations in Rosebud County, Montana. Waters from wells less than 125 feet deep are hard and those from deeper waters are soft. It is believed that the soft waters are derived from the harder waters by a process of natural softening which occurs within 125 feet of surface as they percolate downward, exchange of bases being largely brought about by the mineral leverrierite, a hydrous silicate of aluminum. Other hydrated silicates, such as kaolin, feldspars, and mica may also be effective.—*David G. Thompson.*

A Study of Coastal Ground Water with Special Reference to Connecticut. JOHN S. BROWN. U. S. Geol. Survey Water Supply Paper **537**: 1925, pp. 97, 7 pl. and 20 figs. Primarily a study of contamination of fresh-water-bearing beds by salt water along sea coasts. Discusses hydraulic principles involved in contamination of wells, as shown by experience in Long Island and European well fields. Important facts are: (1) that zone of diffusion between fresh and salt water is narrow, (2) that under heavy pumping the change from fresh to strong salt water may take place in a short time, and (3) that once contamination has occurred it is difficult if not impossible to eradicate it. New data given as to contamination of wells along Connecticut coast. Contains bibliography, including several important foreign publications, of literature of salt water problem, with quotations of some of most pertinent material.—*David G. Thompson.*

The Salton Sea Region, California—A Geographic, Geologic, and Hydrologic Reconnaissance with a Guide to Desert Watering Places. JOHN S. BROWN. U. S. Geol. Survey Water Supply Paper **467**: 292 pp. 1923. Gives special attention to water supplies in desert parts of Riverside and Imperial counties with data on ground water in many parts of the region, including analyses. Discusses vegetation as an indicator of ground water.—*David G. Thompson.*

Preliminary Report on the Geology and Water Resources of the Mud Lake Basin, Idaho. H. T. STEARNS and L. L. BRYAN. U. S. Geol. Survey Water Supply Paper **560-D**: pp. 87–132, October 20, 1925. Gives an inventory of surface and ground water supply of a region underlain by lava beds. In 1908 Mud Lake covered about 2500 acres. By 1914 lake had risen 5 feet and area increased to 14,200 acres. This increase is believed to be due to underground movement of surplus water from liberal subirrigation on Egin Bench, 25 miles distant, as shown by contours of water table. Map of water table contours also shows ground water around Mud Lake to be perched 250 to 275 feet above a lower water table. About 162,000 acre-feet appeared at surface in Mud Lake and vicinity from April 1, 1921, to March 31, 1922. Of this amount about 96,000 acre-feet came from underground sources, 47,000 acre-feet from Camas Creek and 19,000 acre-feet fell as rain or snow. Measurements of

evaporation from land and floating pans and from a pan filled with tules indicated discharge by evaporation and plant growth of 41,000 acre-feet. Evaporation from floating pan was about 75 per cent of that from land pan and from tule-filled pan in growing season much greater than from land pan.—*David G. Thompson.*

Information for Applicants for Construction, Alteration or Repair of Dams. New Jersey Dept. of Conservation and Development, 9 pp. 7 plates. Gives the New Jersey law relating to erection of dams and information, including specimen maps and cross sections, to guide applicants in submitting plans.—*David G. Thompson.*

Biennial Report of the Division of Water Rights, California Department of Public Works. 179 pp., November 1, 1924. Besides usual administrative report, including review of number of decisions on water rights, report contains brief special appendices summarizing investigations on salinity of river water in Sacramento-San Joaquin delta, return waters reaching these rivers, and duty of water in the Great Central Valley. In 1924, although flow of Sacramento River did not get as low as minimum of 1920, the driest previous year, salinity reached higher proportions than in 1920. This was because the low river flows were reached much earlier in 1924 than in 1920.—*David G. Thompson.*

Some Geochemical Relations of Ground Water and Associated Natural Gas in the Lance Formation, Montana. B. Coleman Renick. Jour. of Geology, **32**: 8, 668–684, November–December, 1924. Discusses analyses of water and gas from ten artesian wells in Central Montana. Gases from all ten waters contain 30 per cent, or more, of nitrogen and two contained 95 and 96 per cent respectively. These two contained no methane which was present in remaining samples, being derived from coal and disseminated carbonaceous material in the formations. Reactions between various components of gases and waters are discussed.—*David G. Thompson.*

Ground Water in Musselshell and Golden Valley Counties, Montana. A. J. Ellis and O. E. Meinzer. U. S. Geological Survey Water Supply Paper **518**: 1924, pp. 90, 5 pl. and 11 figs. Describes geology and occurrence of ground water in counties named, with analyses of water from a number of wells and springs. Ground water is used principally for domestic and farm purposes. In parts of region the water yielded is either very scanty or of poor quality, so that cisterns must be used.—*David G Thompson.*

Gaseous Content of Ground Waters as an Aid to the Petroleum and Natural Gas Prospector. G. W. Jones, W. P. Yant, and E. P. Buxton. U. S. Bur. Mines, Serial No. 2553, 15 pp. mimeographed, December, 1923. Analyses of gases dissolved in ground water may be used to show whether oil or gas sands are present in region through which waters passed. This paper describes apparatus and methods used for determining dissolved hydrocarbon vapors in water, gives results of analyses of gas in waters from different localities, and

discusses significance of these with reference to indications of oil and gas.—*David G. Thompson.*

Chemical Character of Ground Waters of the Northern Great Plains. H. B. Riffenburg. U. S. Geol. Survey Water Supply Paper. **560-B**: pp. 31–52, April 2, 1925. Discussion of chemical character of waters in sedimentary formations of northern Great Plains, and of differences noted in waters (1) from different formations, (2) from same formation in different localities, and (3) from different horizons in a formation. It is concluded that waters of meteoric origin have generally replaced original waters of sedimentation. Besides analyses of waters from different formations, report contains original data on analyses of rain water and on effect of rock samples in changing natural waters which were allowed to percolate through them.—*David G. Thompson.*

Construction of Wood Stave Pipe Line. J. B. Holdcroft. Can. Eng., **49**: 1, July, 1925. Details of construction of longest continuous wood stave pipe in Eastern Canada for supplying fresh water. Total length 29,891 feet; diameter 24 inches; creosoted stock employed where buried. Using the formula of Williams and Hazen with c = 125 and checking against recorded flow through venturi meter, figured discharge was just over 2 per cent greater than actual. Record speed construction in Canada was established, 800 feet having been laid in one ten hour day.—*N. J. Howard.*

Organization of Physical Testing Laboratory. Bulletin Topographical survey of Canada. Can. Eng., **49**: 3, July, 1925. Topographical survey of Canada has well equipped laboratory for testing, adjusting, and maintaining standards. Functions of laboratory, importance of work, and description of equipment in the various sections are dealt with.—*N. J. Howard.*

London Waterworks Show Surplus. Extract report of E. V. Buchanan, Public Utilities Commission, London, Ont.; Can. Eng., **49**: 3, July, 1925. Report shows increase in metered residential, industrial, and commercial rates, including hospitals. Unmetered residential rates have dropped owing to fact that few are left unmetered. Results justify plan of metering and exemplify that "when consumer is paying for what he is using, there is a general desire for conservation."—*N. J. Howard.*

Metering of Water Services. Can. Eng., **49**: 3, July, 1925. Reductions in per capita consumption follow metering of water. Buffalo reported 47 per cent, London, Ont., 33 per cent, Cleveland, 46 per cent, and section of Baltimore, 49 per cent.—*N. J. Howard.*

Salt Velocity Method of Water Measurement. C. M. Allen and E. A. Taylor. Can. Eng., **49**: 5, August, 1925. Illustrated article on theory and development of new method of measuring water. Salt solution is introduced near upper end of conduit, and passage of solution by one or more pairs of electrodes, at other points in conduit, is recorded graphically by electrical recording instruments. Passage of salt solution between two points is timed,

and volume of penstock between same points is accurately determined. Discharge in cubic feet per second equals volume so found in cubic feet divided by time in seconds. Authors believe this method to be correct in theory and practice, and that in a few years its simplicity, accuracy, and other advantages will make it an accepted standard method of water measurement.—*N. J. Howard.*

Review of Sanitary Surveys in Ontario. F. A. Dallyn. Can. Eng., **49**: 10, September, 1925. Extract annual report Ontario Provincial Board of Health, 1924. Prior to 1913 only 7 water purification plants existed in Province. This has increased in 1924 to 41 purification plants and 96 chlorine installations. Typhoid fever mortality per 100,000 of population reduced from 31.5 in 1910 to 2.5 in 1924. Figures are given as to expenditures involved in sewage disposal and water purification in a nine year period. Provincial experimental station and laboratory used for instruction and research work and considerable number of valuable publications have been made.—*N. J. Howard.*

Ohio Sanitary Code of the Department of Health of Ohio. Ohio's Health, **16**: 2, 49. Contains 235 regulations adopted by the Public Health Council, August 20, 1925. Code includes regulations concerning water and ice supplies provided by common carriers, and water supplies for railway construction camps and state park sanitary districts. It also provides for submission and approval of plans for water supply, sewerage, industrial wastes, etc.—*G. C. Houser.*

New Regulations for Water and Sewerage Projects. Anon. Public Health News (New Jersey Dept. of Health), **10**: 10, 235, September, 1925. Rules concerning submission of data covering water and sewerage projects to be installed in New Jersey were adopted by State Dept. of Health on August 11, 1925. These rules are a revision of those adopted in 1913. Specific requirements for water treatment plants are concerned with slow sand filters, rapid sand filters, and sterilization units.—*G. C. Houser.*

Résumé of the Goiter Situation. L. C. Scott. Quarterly Bulletin, Louisiana State Board of Health, **16**: 4, 227, December, 1925. Discusses an account of epidemicity of goiter within confines of United States, written by McClendon and Williams. They have attempted to show that certain regions in which goiter prevails extensively also have a water supply with low iodin content. Prevention of goiter by iodizing the drinking water is also discussed. *G. C. Houser.*

Amendments to State Sanitary Code. Health News (N. Y. State Dept. of Health), **2**: 47, 185, November 23, 1925. At meeting of New York Public Health Council, held November 12, 1925, chapter VII of Sanitary Code was amended by adding thereto three new regulations, dealing with following subjects: (1) Certain cross-connections between water supplies not permitted. (2) Permissible arrangements where dual supplies are used. (3) Non-potable water in industrial plants to be rendered unavilable for drinking.—*G. C. Houser.*

Typhoid Outbreak Follows "Intestinal Flu." Anon. Health News (N. Y. State Dept. of Health), 3: 3, 12, January 18, 1926. It has been noted in past that water-borne outbreaks of typhoid fever were frequently preceded by outbreaks of diarrhea. This is one of the principal reasons why a regulation of the State Sanitary Code was adopted, prescribing that an unusual prevalence of diarrhea shall be recorded immediately by local health officer to State Department of Health by telegraph or telephone.—*G. C. Houser.*

Safe Water for the Highways. Anon. Public Health (Mich. Dept. of Health), 13: 11, 306, November, 1925. Plan for protection of Michigan's roadside water supplies was put in operation in July, 1925. Three sheet iron signs were prepared. One large sign reads: "Caution—Drink Only Water Approved by Mich. Dept. of Health." This sign serves as introduction to the smaller "safe" and "not safe" signs to be posted at actual sources of drinking water supplies.—*G. C. Houser.*

The Lake Michigan Survey. L. S. Finch. Monthly Bulletin, Indiana State Board of Health, 28: 10, 146, October, 1925. Field work of bacteriological survey being made by United States Public Health Service of waters of Lake Michigan off Indiana shores was completed during latter part of October. This work is part of a more comprehensive survey, which may be outlined as follows: (1) Sanitary survey of drainage area of Calumet River; (2) Bacteriological study of waters of Lake Michigan and of all public water supplies taken from it; (3) Collection and analysis of available data relative to influence of these water supplies on the public health.—*G. C. Houser.*

Financing Main Pipe Extensions by the Assessment Method. C. M. Saville. Jour. New Eng. Water Works Assoc., 39: 3, 185, September, 1925. Cost of laying pipe mains at Hartford (Conn.) is assessed against property on thoroughfare in which pipe is laid. Approximately one-third of total cost is borne by city, including exemptions, street intersections, oversize pipe, and connections. Discussion is included.—*W. U. Gallaher.*

Period of Storage and Micro-organisms in Reservoirs. R. S. Weston. Jour. New Eng. Water Works Assoc., 39: 3, 225, September, 1925. In general, in uplands of northeastern U. S., reservoirs suffer from microscopic organisms in inverse proportion to storage ratio (capacity divided by mean annual runoff). Surface waters are best which are gathered quickly and stored for a long period.—*W. U. Gallaher.*

A Score System for Grading Water Supplies According to Sanitary Conditions. E. S. Chase. Jour. New Eng. Water Works Assoc., 39: 3, 229, September, 1925. Perfect score of one hundred divided between three main heads, viz.—pollution hazards, 50; protective measures, 20; and quality conditions, 30. Scoring of each part depends on source of supply. Discussion follows.—*W. U Gallaher.*

Pumps Need Constant Watching. Power Plant Engineering, 80: 1, 74, January 1, 1926. Valves, packings, and bearings are principal problems in

pump maintenance. Rules for operation and care of both centrifugal and reciprocating pumps are outlined.—*W. U. Gallaher.*

Feed Water Systems. Power Plant Engineering, 80: 1, 45, January 1, 1926. Review of methods for purification of boiler feed water. Includes filtration, preheating, softening by hot and cold lime—soda processes and by zeolite process, evaporation, deaëration, deactivation, and internal treatment by compounds, etc. A recent method consists in continuously withdrawing, filtering, and returning a portion of the boiler water. Acid is added in some plants to reduce causticity of zeolite-softened water.—*W. U. Gallaher.*

Lake Erie Water Purified for Monroe, Mich. Anon. Power Plant Engineering, 29: 16, 828. August 15, 1925. This city of 14,000 has replaced its original pumping station by a low-lift station taking water from Lake Erie and pumping it three and one-half miles further to filtration plant. An additional crib has been constructed to alleviate trouble from needle ice. Filtration plant consists of coagulation basin with four independent compartments, each of which can be removed from service, four 1-m.g.d. filter units, and 3-mg. covered storage reservoir. First runnings from filters are stored and used later for filter-washing. Plant uses dry feed alum machines and disinfects with liquid chlorine. Dosage of alum varies from 0.7 to 4 grains per gallon and of chlorine from two to six pounds per million gallons. Two motor driven, single-stage, centrifugals are arranged to pump either wash water for filters, or waste to river. Two crank and fly-wheel pumping units, of 3- and 5-m.g.d. capacity, respectively, deliver water to mains. As auxiliary to these a 2-m.g.d. centrifugal has been installed. Uniflow engine direct connected to alternator furnishes power to electrically driven units. Boilers and their equipment are described.—*W. U. Gallaher.*

The Wheeling, West Virginia, Filtration Plant and Some Operating Results. J. F. Laboon. Jour. New Eng. Water Works Assoc., 39: 4, 291, December, 1925. Wheeling had suffered for a long time from effects of impure water. Many plans for improvement had been recommended and two bond issues defeated. In 1922, due to extensive publicity campaign for pure water, bond issue passed. Water works improvements include filtration plant, pumping station, intake works, many large mains with cross connections, 5-m.g. reservoir, and purchase of four private water plants. Water consumption was at the rate of 400 gallons per capita per day: due to metering it has been lowered as follows:—1923, 17.3 m.g.d.; 1924, 15 m.g.d.; first three months 1925, 12 m.g.d. Predicted that with 100 per cent metering it will be 12 m.g.d. Source of supply is the heavily polluted Ohio River. Filtration plant has capacity of 20 m.g.d. and can be adapted for softening. Includes 850,000-gallon grit chamber, 415,000-gallon mixing chamber, two settling basins with combined capacity of three and one-third million gallons, ten 2-m.g.d filters, and 570,000-gallon clear water reservoir. Water may be by-passed around either grit or mixing chamber or both. Mixing chamber has five stationary concrete baffles and five adjustable wooden ones. Settling basins may be operated in series, in parallel, or separately. Filters have concrete false bottom instead of pipe lateral underdrains.

Master control for setting all controls is provided in addition to master rate-of-flow gage and samplers. Wash water is stored in 125,000-gallon steel tank automatically kept full. Plant has many conveniences for unloading chemicals. Lime and iron, or alum, are fed by five dry feed machines. Water injector is used to clean chemical line. Since February, 1925, when plant was put in operation, bacterial removal, 37°C., has averaged 84 per cent. Alkalinity of water is low and is kept at 10 p.p.m. Curves are given showing fluctuations in hardness, alkalinity, carbonic acid, and turbidity; dosage of iron, lime, and alum; length of filter runs; and percentage wash water used. Total cost of filtering $6.38 per million gallons. Total cost, including pumpage, but excluding fixed charges, $22.98. Cost of plant $604,940: of entire system, $1,763, 460.—*W. U. Gallaher.*

Tastes in the Water Supply of Marquette, Mich., Due to Phenol Wastes. Paul Hansen. Jour. New Eng. Water Works Assoc., **39**: 4, 320, December, 1925. History dating from 1901 is given of the occurrences and consequent investigations of tastes in water supply caused by dumping of phenol wastes in vicinity of intake. Following are suggested as solutions to problem:—(1) establishment of intake beyond reach of wastes; (2) diversion of wastes beyond reach of present intake; (3) treatment of wastes at plant; (4) treatment of water supply to eliminate tastes; and (5) mixing wastes with city sewage. Taste-producing waste can be carried a greater distance by low than by high velocity wind. Depth of circulation due to temperature is about two hundred feet; so that within practicable limits, at no place in Marquette Bay could intake avoid wastes. Pumping wastes to Middle Bay would meet with objections from that locality. Experimental treatment reduced wastes about 50 per cent; mixing with sewage, 75 per cent. Partial treatment of wastes and subsequent mixing with city sewage seems most feasible plan.—*W. U. Gallaher.*

Moving a 100,000-Gallon Steel Tank a Quarter of a Mile. J. D. Keiley. Railway Engineering and Maintenance, **21**: 9, 343, 1925. A 100,000-gallon elevated steel tank, 70 ft. high, was moved one-quarter mile at the C. &. O. Railway Russell Terminal and placed on new foundation by local forces. Detailed description of the supports and method of jacking and cribbing is given.—*R. C. Bardwell.*

Railroad Reservoir in Kansas Provides Large Ice Harvest. Anon. Railway Engineering and Maintenance, **21**: 9, 358, 1925. 4,975 tons of ice were secured, loaded, and stored from 200,000,000 gallon reservoir of Missouri Pacific Railway at Hoisington, Kansas, effecting net saving of $8,691.00.—*R. C. Bardwell.*

Building a Large Intake Pipe Line in Lake Michigan. C. R. Knowles. Railway Engineering and Maintenance, **21**: 12, 488, 1925. New line is 24-inch c. i. pipe, 650 feet long, with flexible ball joint every 48 feet from suction well to lake intake. Pipe was put together and loaded in 48-foot sections on barge, connected to previous ball joint, and then lowered with derrick. Inspection and leveling were handled by diver. Pipe was increased to 30-inch with galvanized screen where it passed through rock filled breakwater. Photographs and plans are shown.—*R. C. Bardwell.*

Should Hydrants Be Packed Without Sawdust? E. M. Grime and H. P. Blake. Railway Engineering and Maintenance, 21: 12, 501, 1925. Sawdust has been found to cause lead corrosion when moist. Full ground cover with proper drainage from base of hydrant pit with dead air space and false cover is recommended.—*R. C. Bardwell.*

Concrete Tanks Like New After Twenty Years' Use. Anon. Railway Engineering and Maintenance, 21: 9, 356, 1925. On Atlantic and West Point, and Western Railway of Alabama, respectively, 50,000-gallon reinforced concrete water tanks at Hogansville, Ga., and Natasulga, Ala., have been in continuous railway water service since 1905. The interesting feature is lightness of design. Tanks are cylindrical, 29 feet dia. by 12 feet high, on 13 feet high, 13 concrete post frame. Floor is 5 inches thick, side wall, 4 inches, and dome roof 2 inches. Reinforcing is $\frac{3}{16}$, $\frac{1}{4}$, and $\frac{5}{16}$ bars. Mix is 1:2:4. Three $\frac{1}{4}$-inch coats of 1:1 mortar were applied to interior walls and floor. No other water proofing was used. Tanks are still in first class condition.—*R. C. Bardwell.*

New Lackawanna Water Station Shows Low Operating Cost. H. W. Machemer. Railway Review, 77: 10, 354, and Railway Engineering and Maintenance, 21: 10, 377, 1925. The D. L. & W. R. R., recently rebuilt water station at Groveland, N. Y. Two 150 h.p. locomotive type boilers and steam plunger pumps were replaced by two 50 h.p. and one 15 h.p., Type "Y" crude oil engines, and 6-inch single stage centrifugal pumps. Change from steam to fuel oil effected large operating saving. Lime and soda ash treatment facilities consist of intermittent plant with air agitation and subsequent filtration through pressure filters. Three 85,000-gallon flat bottom steel tanks are used for treatment. Four hour sedimentation period is provided.—*R. C. Bardwell.*

Missouri-Kansas-Texas Improves Water Supplies. J. H. Davidson. Railway Age, 79: 10, 445, 1925; Railway Engineering and Maintenance, 21: 8, 309, 1925. Comprehensive program for improvement of water supply quality on M. K. & T. R. R. system has effected marked improvement in locomotive performance. Prior to 1916 various boiler compounds were used with inconsistent results. At close of 1923, 35 complete lime and soda ash softeners and 52 soda ash plants were in service, at 60 per cent of water stations, and 65 per cent of water used was treated. Complete softeners are of continuous type with various feeding arrangements. Reduction in boiler failures has amounted to between 85 and 97 per cent. Saving in fuel varies from 6 to 14 per cent for different classes of service. Improved water conditions have helped to make possible increase in continuous locomotive run of from 275 to 869 miles. Photographs, diagram, and charts are included.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Water Softening Developments—Rock Island Lines. P. M. LaBach. American Railway Engineering Association Bulletin, 27: 277–87, 1925. Detailed laboratory experiments and results from water softening plants at Council Bluffs, Ia., and Estherville, Ia., indicate that less material can be used with better results and greater reduction in harness if Na_3AlO_3 is added

to the water separately from the lime and soda ash.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

A Thousand Dollars for the Best Answer. CHARLES DILLON. Railway Review, **77**: 23, 833, 1925. Pitting and corrosion is causing acute trouble in Railway locomotive boilers. Railway Review is offering cash prize for best solution offered, on or before March 31st, 1926.—*R. C. Bardwell.* (*Courtesy Chem Abst.*)

Committee Report on Feed Water Heaters. Anon. Railway Review, **77**: 23, 853, 1925. Report presents discussion of open and closed types, exhaust steam injectors, and direct methods for steaming locomotives. Proportional feed of chestnut bark extract is recommended for reducing scale troubles in closed system. Non-corrosive coating is suggested for protecting steel parts from pitting. A trouble common to both types is scale formation found at opening to boiler beyond the check valve. This should be cleaned every 90 days.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Treated Water Increases Locomotive Efficiency. R. C. BARDWELL. Railway Review, **77**: 18, 669. Railway Age, **79**: 17, 769, 1925. General paper on methods of water softening as applied to Railway use. Estimated figures are given on consumption and cost data.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Providing a Railroad's Water Supply. R. C. BARDWELL. Railway Age, **79**: 11, 517, and 20, 885, 1925. Increasing attention given to water quality and pumping equipment are reducing railway transportation costs. Various features of treating and pumping equipment are discussed.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

A Study of the Effects of Anions upon the Properties of "Alum Floc." L. B. MILLER. Public Health Reports, **40**: 8, 351, February 20, 1925. Importance of negative ion content of solution in relation to some of chemical and physical properties of alum floc is established. Bearing upon water purification by alum process is discussed. In this connection the effect of several negative ions upon form of electrometric titration curve is demonstrated. Relation of hydrion concentration and anion content of solution to formation of aluminum precipitate is determined for several anions. Dependence of physical state of insoluble aluminum compounds formed—their existence in colloidal suspension or as coagulated precipitate—upon anions present is emphasized. Lack of agreement in literature upon region of hydrion concentration in which coagulation of alum takes place is explained as partially due to negative ion content of solutions in question and to presence of colloidal material such as silicic acid or organic matter. Relation of "hydrion zone of coagulation" to "hydrion zone of rapid coagulation" for aluminum sulphate and aluminum chloride is determined. For aluminum sulphate it is demonstrated that "hydrion zone of rapid coagulation" tends to shift towards more acid portion of "hydrion zone of coagulation." A few possible applications of the principles

discussed in this paper are pointed out, and in particular the coördinate importance of the aluminum ion and of the sulphate ion for current water works practice is emphasized. A bibliography is appended.—*Aug. G. Nolte.*

Report of Advisory Committee on Standards for Drinking Water Supplied to the Public by Common Carriers in Interstate Commerce. Public Health Reports, 40: 15, 693, April 10, 1925. Committee composed of representatives from government departments and scientific associations and of eminent sanitarians. Recommendations submitted apply only to a special case, i.e., of formulating definite specifications which may be used by Public Health Service in administrative action which it is required to take upon supplies of drinking water offered by common carriers for use of passengers carried in interstate traffic. Committee has taken the better class of water supplies of municipalities as its standard of comparison with respect to safety. Proposed standards recommend requirements, (1) As to source and protection; (2) As to bacteriological quality and (3) As to physical and chemical characteristics. As regards first requirement, sanitary survey of the water supply should be made by a competent person; brief general description of water supply should be submitted and brief summary of pertinent facts relating to sanitary condition of supply, as revealed by field survey, should be submitted. As regards second requirement, committee have proposed omission of plate counts and inclusion only of quantitative estimation of organisms of B. coli group by applying specific tests to multiple portions of measured volume. As regards third requirement, committee have defined a satisfactory water as one that is clear, colorless, odorless, pleasant to the taste, free from toxic salts, free from an excessive amount of soluble mineral substances and free from an excessive amount of chemicals employed in treatment. Maximum allowable values are given for physical and chemical characteristics of acceptable water supplies.—*Aug. G. Nolte.*

Highway Signs to Show City has Approved Water Supply. Public Health Reports, 40: 16, 787, April 17, 1925. Minnesota State Board of Health posts signs on highways approaching municipalities having water supplies approved by State Board of Health. Supplies investigated once each year. Signs removed if at any time water supply is found unsatisfactory.—*Aug. G. Nolte.*

The Supplying of Drinking Water to Vessels in the United States. J. I. Connolly. Public Health Reports, 40: 21, 1042, May 22, 1925. In this paper are outlined briefly some of water supply problems of American vessels in coastwise, river, and Great Lakes services. Two distinct divisions of the vessel water supply problem are recognized: (1) Where water is obtained from sources ashore, and (2) where it is taken from overboard. Given a satisfactory source ashore (a safe water), question of getting water aboard in sanitary manner and of storing and distributing it properly is of vital importance. Water taken on vessels from overboard is delivered through seacocks, located below water line. Methods of treating "overboard" water to be used for drinking purposes are distillation, treatment by ultra-violet rays, by ozone, and by hypochlorites. Filtration as preliminary treatment is required for

efficient disinfection in all cases except the first, since raw water may at times contain considerable organic matter in suspension.—*Aug. G. Nolte.*

Some Properties of Iron Compounds and Their Relation to Water Clarification. L. B. MILLER. Public Health Reports, 40: 27, 1413, July 3, 1925. In summary of this paper it is stated that,—"(1) The electrometric titration curve of ferrous sulphate by alkali has been determined; (2) The composition of the precipitate from ferrous sulphate at varying hydrogen ion concentrations has been determined in a nitrogen atmosphere; (3) The titration curves of ferric alum and ferric chloride by alkali have been made, using colorimetric methods; (4) The composition of the precipitate from ferric alum at varying hydrogen ion concentrations has been determined. The precipitate from ferric chloride did not lend itself to this type of analysis; (5) The ranges of hydrogen ion concentration over which precipitation occurs with ferric alum and ferric chloride has been determined; (6) The relation of these experimental facts to water clarification by copperas has been discussed. The importance of these data as a basis for a further study of principles has been pointed out."—*Aug. G. Nolte.*

Notes on the Clarification of Colored Waters. L. B. MILLER. Public Health Reports, 40: 28, 1472, July 10, 1925. A number of samples of water containing "color" of the humic acid type from several sources were studied in some detail by three different methods of experimentation; namely, (1) by dialysis, (2) by cataphoresis, and (3) by the study of the effect of various chemical reagents upon the stability of the "color" in solution. In every case investigated the color proved to be present as negatively charged colloid. The coagulation and removal of the "color" (formation of the "color floc") by electrolytes was shown to be effected by the cation. With respect to the clarification of colored waters by alum, it was suggested that the clarification was due to aluminum ion and that "alum floc" which is effective in the clarification of turbid waters, had an unimportant rôle in the removal of "colors" of this type. The conditions most favorable for color removal by alum were discussed. Possible limitations in the application of the principle were pointed out.—*Aug. G. Nolte.*

Dual Water System Responsible for Typhoid Case. Public Health Reports, 40: 34, 1763, August 21, 1925. Case occurred in an industrial plant in Niagara Falls. In addition to municipal water supply connected with drinking fountains, company had private supply obtained directly from Niagara River. This water was filtered but not chlorinated. Water faucets for wash basins in rest rooms were found connected with this supply. As no warning notices had been posted, it was stated to have been common practice for employees to drink this water. Analysis showed water to be badly polluted. Warning notices then posted.—*Aug. G. Nolte.*

Stream Pollution by Wastes from By-Product Coke Ovens. R. D. LEITCH. Public Health Reports, 40: 39, 2021, September 25, 1925. General review of subject is given. Effect, extent, and sources of pollution as well as methods of disposal and cost of systems are discussed.—*Aug. G. Nolte.*

Year's Progress in Power Field Shows Many Marked Advances. Power, 63: 1, 2, January 5, 1926. Remarkable reduction in fuel consumption shown in many recent innovations in equipment and station design. Air preheating and water cooled walls prominent in furnace design. Improved metals give preference to high temperatures over high pressures. Present limitations and status of various auxiliaries, fuels and combustion, and steady growth of steam turbines are discussed. Steam engine to remain an important factor for some time to come. Much activity shown in internal-combustion engine industry and in water power development. No radical changes in electrical apparatus.—*Aug. G. Nolte.*

Wood Refuse Burned on Underfeed Stokers. C. M. Garland. Power, 63: 2, 46, January 12, 1926. Illustrated.—*Aug. G. Nolte.*

Why Boiler Tubes Burnt Out. George C. Reinhard. Power, 63: 2, 51, January 12, 1926. Scale removal resulted in tube failure. Various theories investigated. Conclusions drawn from investigation were that corrosion was due to external cause; that external superheating could not be responsible in view of interior condition of tubes; that oil jets were not responsible; that blistering and blowout were due to corrosive action caused by combustion and oxidation of sulfur to sulfuric acid, which corrosion, in conjunction with fusion of products of corrosion, weakened the tubes; that cause could be traced directly to sulfur content of oil. Recommendations made were reduction or elimination of sulfur in oil and frequent external cleaning of tubes.—*Aug. G. Nolte.*

Recooling Oil-Engine Jacket Water. Edgar J. Kates. Power, 63: 2, 57, January 12, 1926. Simplest method is to expose water to air in "open cooling systems." Cooling sprays cool by dividing water into small drops, thus increasing surface exposed to air. In all cases cooling effect is accomplished mostly by evaporating part of water and thus cooling remainder. Some of heat of water is delivered directly to the air, thus cooling water by heating air. Open cooling system has one serious defect where water is hard, that is, when it contains scale forming minerals in solution. As cooling is accomplished by evaporation and as only pure water evaporates, dissolved minerals are left behind, thus causing remaining water to become more concentrated in mineral salts. When such water is heated in engine jackets, it is unable to retain all the mineral matter in solution, whereupon scale is deposited on jacket walls. Dead Sea in Asia Minor is striking example of results of continuous evaporation, as solids in solution that body of water now make up one-quarter of entire weight of water.—*Aug. G. Nolte.*

Engineering Bulletin No. 2. Maryland State Department of Health. September, 1925. **Values in the Control of Environment.** Abel Wolman. 6–14. **Hygienic Aspects of the Use of Sewage Sludge for Fertilizer.** Abel Wolman 15–32. **Preliminary Observations on Lime Treatment of Sewage Sludge.** T. C. Schaetzle. 33–42. **Studies of Sewage Treatment Plant at the Maryland House of Correction, 1920.** Charles R. Coff. 43–54. **A Study of the Qualities of Limestone for Use on Sewage Trickling Filters.** T. C. Schaetzle. 55–62.

Report on Sanitary Privy Construction and Maintenance. FRED W. CASPARI. 63–72. **Water and Sewage Construction at State Institutions.** GEORGE L. HALL. 73–86. Under provisions of the water supply and sewerage law of 1914, the Bureau of Sanitary Engineering has made water and sewerage improvements at state institutions, the total cost of which amounted to $227,496 in 1924, exclusive of engineering costs. Description of work at various institutions is given. **Garbage Incinerator for Camps.** A. P. GWYNN. 87–89. **The Occurrence of Tastes and Odors in Hyattsville Water District System after Painting Elevated Tank.** ABEL WOLMAN. 90–92. Investigation indicated the following combination of circumstances as responsible for unusual tastes and odors: use of coal-tar paint, some of whose constituents were soluble in water; placing elevated tank in service before paint hardened; use of 1 p.p.m. chlorine within tank, in addition to a dosage of 0.4 p.p.m.; low temperature of water supply. **Effect of Oil of Chenopodium on Fish Life.** T. C. SCHAETZLE. 93–102. **Effect of Chemically Treated Water on Goldfish.** A. P. GWYNN. 103–104. Study indicated that super-saturation of oxygen in water and not chemical treatment was responsible for fish mortality. Fish life is not affected seriously either by chlorine as high as 3 p.p.m. or by sulfuric acid, copper sulfate, or alum in doses higher than usually employed. **Analytical Study of the Waters of Antietam Creek.** T. C. SCHAETZLE. 105–141. **Some Problems in Industrial Wastes Treatment.** T. C. SCHAETZLE and S. T. POWELL. 142–148. Outline of problems in and around Baltimore City as presented before American Chemical Society meeting April 9, 1925. **Treatment of Wastes from Congoleum Manufacturing.** T. C. SCHAETZLE. 149–156. **Float Investigations on Susquehanna River at Havre de Grace.** A. P. GWYNN. 157-161. **Study of Sewage Pollution of Sinepuxent Bay.** ABEL WOLMAN, A. E. GOODRICH and W. N. SPRING. 162–168. **Metropolitan District Planning in Maryland.** ABEL WOLMAN. 169–178. Total population in Maryland, exclusive of Baltimore City, now under unified or metropolitan management for water supply, sewerage, storm-water drainage, and refuse disposal totals over 100,000. Method of financing provides for accumulation of funds from taxes, special assessments, and service rates. Special assessments developed on front-foot basis and provide for fixed charges. Increase in tax rate covers approximately fixed charges on cost of reservoirs, pumping plants, etc., which may be assumed to be community benefits. Service rates provide for maintenance and operation charges.—*A. W. Blohm.*

NEW BOOKS

Elementary Guide to Reinforced Concrete. LAKEMAN, ALBERT. London: Concrete Publications Ltd. Paper; 6 x 9 in.; pp. 69; 79 linecuts. 2s. Reviewed in Eng. News Rec., 95: 645, 1925.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Concrete, Plain and Reinforced, Vol. I. TAYLOR, FREDERICK, THOMPSON, W., SANFORD E., and SMULSKI, EDWARD; with a chapter by ROBBINS, HENRY C. 4th Ed. New York: John Wiley & Sons Inc., London: Chapman & Hall,

Ltd. Cloth; 6 x 9 in.; pp. 969; 311 line cuts. $8. Reviewed in Eng. News Rec., 95: 642, 1925.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Provvista e Distribuzione di Acqua Potabile. CLAUDIO MISTRANGELO. Milan: U. Hoepli. 389 pp. L. 36. From Chem. Abst., **17**: 2929, September 10, 1923.—*R. E. Thompson.*

Public Utilities and the Law. WM. M. WHERRY, JR. New York: The Writers' Publishing Co., Inc. Cloth; 5 x 8 in.; pp. 337. $3. Reviewed in Eng. News Rec., **95**: 643, October 15, 1925.—*R. E. Thompson.*

Zur Bestimmung Strömender Flüssigkeitsmengen im offenen Gerinne. O. POEBING. Berlin: Julius Springer. M. 1.70. Reviewed in Wasser u. Gas, **14**: 188, 1924. From Chem. Abst. **18**: 1026, April 10, 1924.—*R. E. Thompson.*

Über Wasserversorgungsanlagen. F. SCHLOTTHAUER. 3rd. Ed. Munich and Berlin: R. Oldenbourg. M 3-M 4. Reviewed in Gesundh. Ing., **46**: 164, 1923. From Chem. Abst. **18**: 1026, April 10, 1924.—*R. E. Thompson.*

Kalender für das Gas- und Wasserfach. G. THIEM. Vol. 47. Munich and Berlin: R. Oldenbourg. Reviewed in Gesundh. Ing., **47**: 30, 1924. From Chem. Abst. **18**: 1046, April 10, 1924.—*R. E. Thompson.*

Analysis of Potable Waters. P. MOLLIEX. Paris: Libraire le François. 91 Bvd. St. Germain. pp. 96. F 4. From Chem. Abst., **18**: 1355, May 10, 1924.—*R. E Thompson.*

The Composition of the River and Lake Waters of the United States. FRANK WIGGLESWORTH CLARK. U. S. Geol. Survey Professional Paper 135: 199 pp. 1924. This report contains several thousand analyses of some 650 different river and lake waters in the United States, with discussion of relations between waters and nature of rocks in which they originated. As was to be expected from so eminent an authority on geochemical data, a large amount of valuable information is included. Introduction considers relative value of different forms of statement of water analyses, and problems arising in interpretation of analyses. All analyses are stated in ionic form in parts per million and many in addition are also given in percentages. Under discussion of interpretation of analyses are considered such subjects as: value of analyses from different sources; source of a water—whether it is a "simple water" originating in an area of rocks of uniform lithologic character, or a "blend" or mixture of waters originating from rocks of different characters, such as are brought to a trunk stream by tributaries—; variations in composition of a river water from time to time and from place to place; relative quantities of various salts in waters; and significance of different constituents. Tables of analyses, with accompanying interpretations, are arranged by drainage basins. For many of the more important streams 30, or more, analyses covering ten-day periods for at least a year are given.—*David G. Thompson.*

En ny indikator a vattenförorening. (A New Indicator of Water Pollution. —Abstr.) H. Huss. Göteborg: Oscar Briscon. 31 pp. Reviewed in Gesundh. Ing., **46**: 496 (1923). From Chem. Abst., **18**: 1355, May 10, 1924.—*R. E. Thompson.*

Kalender für Gesundheitstechniker. H. Rechnagel. Munich and Berlin: R. Oldenbourg. Reviewed in Wasser u. Gas, **14**: 147, 1924. From Chem. Abst., **18**: 1355, May 10, 1924.—*R. E. Thompson.*

An Introduction to the Methods of Economic Statistics. William Leonard Crum and Alson Currie Patton. Chicago and New York: A. W. Shaw Co. Flexible; 6 by 9 inches; pp. 493. $6. Reviewed in Eng. News-Rec., **95**: 126, January 21, 1926.—*R. E. Thompson.*

Statistical Method. Harry Jerome. New York and London: Harper & Brothers. Cloth; 6 by 9 inches; pp. 395. $4. Reviewed in Eng. News-Rec., **96**: 126, January 21, 1926.—*R. E. Thompson.*

Elements of Business Statistics. Robert Riegel. New York and London: D. Appleton & Co. Cloth; 6 by 8 inches; pp. 549. $4. Reviewed in Eng. News-Rec., **96**: 126, January 21, 1926.—*R. E. Thompson.*

Guiding Principles of Public Service Regulation. Henry C. Spurr. Vol. II. Rochester, N. Y.: Public Utility Reports, Inc. Cloth; 6 by 9 inches; pp. 750. $7.50. Reviewed in Eng. News-Rec., **96**: 127, January 21, 1926.—*R. E. Thompson.*

Public Health Law: A Manual of Law for Sanitarians. James A. Tobey. With foreword by Charles V. Chapin. Baltimore: Williams & Wilkins Co. Cloth; 6 by 9 inches; pp. 304, $4.50. Reviewed in Eng. News-Rec., **96**: 127, January 21, 1926.—*R. E. Thompson.*

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

Vol. 15 APRIL, 1926 No. 4

CONTENTS

OFFICERS OF THE AMERICAN WATER WORKS ASSOCIATION

OFFICERS OF THE
AMERICAN WATER WORKS ASSOCIATION (Continued)

Central States Section.—President, JOSEPH W. ELLMS; Vice-President, CHESTER F. DRAKE; Secretary, E. E. BANKSON; Trustees, J. C. BEARDSLEY, D. C. GROBBEL, MENTOR HETZER.

4-States Section.—President, EDGAR M. HOOPES, JR.; Vice-presidents, V. BERNARD SIEMS, L. VAN GILDER; Secretary-Treasurer, CHARLES R. WOOD; Executive Committee, N. E. BARTLETT, W. H. BOARDMAN, H. D. BROWN, J. W. LEDOUX, GEORGE MCKAY, and the officers.

Illinois Section.—Chairman, W. R. GELSTON; Vice-Chairman, G. C. HABERMEYER; Treasurer, H. E. KEELER; Trustees, H. M. ELY, L. R. HOWSON, C. M. ROOS,

Indiana Section.—Chairman, J. O. ENDRIS; Vice-Chairman, WM. LUSCOMBE; Secretary-Treasurer, C. K. CALVERT; Assistant Secretary-Treasurer, B. J. T. JEUP.

Iowa Section.—Chairman, HOMER V. KNOUSE; Vice-Chairman, J. W. MCEVOY; Secretary-Treasurer, J. J. HINMAN, JR.; Directors, THOS. J. SKINKER, C. D. HAYS.

Kentucky-Tennessee Section.—Chairman, C. E. DAVIS; Vice-Chairman, W. S. PATTON; Secretary-Treasurer, F. C. DUGAN; Directors, F. W. ALBERT, W. H. LOVEJOY.

Minnesota Section.—Chairman, J. A. CHILDS; Vice-Chairman, FELIX SELIGMAN; Secretary-Treasurer, ARTHUR F. MELLEN; Trustees, OLE FORSBERG, A. D. HORNE, E. MCCULLOH.

Montana Section.—J. F. WILLETT, President; H. B. FOOTE, Secretary-Treasurer.

New York Section.—President, B. B. HODGMAN; Secretary, E. D. CASE; Board of Governors, E. D. CASE, B. B. HODGMAN, F. T. KEMBLE, THADDEUS MERRIMAN.

North Carolina Section.—President, J. O. CRAIG; Vice-President, M'KEAN MAFFITT; Secretary-Treasurer, THORNDIKE SAVILLE; Executive Committee, G. F. CATLETT, E. G. MCCONNELL, H. E. MILLER, A. O. TRUE, W. E. VEST, and the officers.

Wisconsin Section.—Chairman, W. D. LEONARD; Vice-Chairman, EDWARD BROWN; Past Chairman, L. A. SMITH; Secretary-Treasurer, C. M. BAKER; Director, WILLIAM KOEHN.

// JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

VOL. 15 APRIL, 1926 No. 4

INTERSTATE POLLUTION OF STREAMS[1]

By H. M. Beardsley[2]

Like many another problem of existence, the pollution of drinking water supplies has progressed from the individual, through the local or neighborhood, to the interstate, national and international stage. The progression, however, seems to have been only one of quantity and area, and not one towards improvement in the principle involved, nor towards the practice of that Golden Rule which we all admit would regenerate the world and which we all say we would follow, if the other fellow would begin. For after all, what difference in principle is there between the vindictive farmer who throws a dead cat in his neighbor's well and the manufacturing plant or the city which discharges its wastes (known to be detrimental to health) into a stream which supplies other human beings with drinking water.

You may say that the filter plant can take care of all that and give us a perfectly good water. They accomplish wonders, it is true—all honor to the sanitarians who have worked out the methods and to the plant operators who carry on the work—but because we have surgeons to set broken bones, we do not break any bones if we can help it.

"Interstate Stream Pollution" as applied to Elmira means what we get from Pennsylvania through the south branch of the Chemung

[1] Presented before the New York Section meeting, January 21, 1926.

[2] General Manager, Board of Water Commissioners, Elmira, New York.

River known as the Tioga River, which has a drainage area of 1330 square miles, nearly all in Pennsylvania, and, to be perfectly fair, what we give Pennsylvania towns and cities through the discharge of our sewers into the Chemung River which flows into the Susquehanna River at Athens, Pennsylvania just over the State line.

The total Pennsylvania population on this water shed is not over 30,000 and as our own New York city of Corning, population about the same, discharges its sewage into the Chemung River only 16 miles above our intakes, I shall not attempt to charge up to interstate pollution any of our sewage troubles.

We have had, however, three distinct and, what might have been disastrous, episodes within the last 13 months which are directly chargeable to pollution from outside the state. Although I said "disastrous," I can not make a thrilling story out of this, nor set up a series of events which will tend to show how clever we are in Elmira in getting out of a bad hole. The history is just this:

On December 9, 1924, we were running along as usual, pumping raw water from the Chemung River to our filter plant. The color was 8, the raw water alkalinity was 89. The sulphate of alumina being used was 0.64 grain per gallon and chlorine 0.048. On the 10th, the color rose to 15 and the water had a distinctly dark brown or blackish color. Knowing of the existence of tanneries just over the line, we suspected tannic acid and tannery liquor. This was confirmed. The alkalinity fell to 86. The alumina and chlorine, which had been lower early in the day, were increased and we were holding our own on output. The wash water used was 4.08 per cent. The next day, the 11th, the color rose to 30, the alkalinity dropped eleven points to 75. The alumina required jumped nearly 60 per cent, the wash water 27 per cent, the output was clear, but not absolutely perfect and we were worried.

We shall take a moment here to outline supply conditions in Elmira. From 65 to 75 per cent of our raw water is pumped from the aforementioned Chemung River. The balance, or all we can possibly squeeze out of it, comes from a storage reservoir on Hoffman Creek, a creek which is absolutely dry in summer and in winter. This reservoir holds about 100,000,000 gallons and we endeavor to keep 60 or 70 m.g. in it as a reserve in case of emergency. This means that we can use very little water from it except when water is coming in during the fall rains, the January thaw or in the spring. In December, therefore, we had no surplus water to use as far as

making a regular run. It was necessary to keep up output, however, and there was nothing to do except to use enough storage water to dilute the river water to a point where it could be handled by the plant and trust that nothing would arise to force us to abandon the river supply entirely. The dilution was made about $\frac{1}{3}$ storage water and $\frac{2}{3}$ river water. The color dropped from 30 to 20, the alkalinity rose 3 points, the wash water and alumina dropped and in a day or two matters were normal again. The matter was brought to the attention of the State Board of Health which had some correspondence with the Pennsylvania Board of Health and we expected our troubles were over.

Then suddenly in the middle of the summer (1925) when the river was very low, we had a second dose, worse than the first. The color climbed rapidly up to 30 and stayed there two days, going off gradually to normal (July 11 to 16). We had little spare water in storage and did not want to use any except as a last resort, but after various attempts, on the 14th we started with a fifty-fifty supply. Because of the warmer weather, our chemical reactions were better and by using over 2 grains of alumina per gallon, washing filters twice as often as usual and running more hours, we turned out a potable, safe and clear water. (Elmira rate 150 mil. gal. per acre).

This time we did not hesitate to kick because the frequency ratio was getting too high. On July 14 I wrote to Mr. Holmquist, Director of the Bureau of Sanitation, New York State Board of Health, as follows:

> The old trouble with the Pennsylvania tanneries waste cropped up again yesterday and was so bad last night that we had to shut down our plant.
>
> I wired you this morning thinking that you might like to see actual conditions and hoping that you might be able to send a representative to look into the matter. I knew you would be interested and in view of what you told me at Louisville about the expected coöperation with the Pennsylvania Board of Health, I thought that first hand information by your Department might be very useful.

He sent me a copy of a letter from W. L. Stevenson, Chief Engineer of the Pennsylvania State Department of Health. I will read part of that letter and I want you please to notice there is coöperation there:

> Pursuant to the provisions of the New York-Pennsylvania Interstate Stream Conservation Agreement, I desire to inform you concerning the pollution of the Tioga River at Blossburg, Pa., by the discharge of contents of vats

at an abandoned tannery, because the Tioga River joins the Cowanesque River at or near the New York-Pennsylvania State Line and thence the waters thereof flow to the Chemung River in New York State.

On July 15, we received a letter reporting that it was rumored that tannery wastes had been discharged to a stream from a tannery in Blossburg and the writer said he would investigate and asked for our official complaint forms.

This morning's mail brings me a letter from our District Engineer who heard of the same matter, and on July 16 visited Blossburg, found that the tannery which had been abandoned for four years is being dismantled and cleaned, with the intention of converting it into a factory. He reports that the first evidence of tannery waste in the stream was noticed on July 8, and apparently between that date and the time of his visit practically all of the vats had been emptied into the stream, and at the time of his visit the stream had a very much higher rate of flow because of rains just previous.

This matter will be brought to the attention of the Sanitary Water Board at its next meeting and such action taken as the Board deems proper.

Mr. C. R. Cox of the New York State Health Department made his survey and made his report. He says:

It was learned that the river water on the morning of July 13, 1925, gave indication of containing much larger quantities of tannery wastes than normally and by 7:00 p.m. of the same day, the filtration plant had to be shut down because of its inability to purify the water at that time. Attempts were made during the night to start the filtration, but conditions were such that satisfactory results were not obtained until about 9:00 a.m. on July 14, at which time the filtration plant was started to treat a mixture of ½ volume river water and ½ volume of water from the impounding storage reservoir, on Hoffman Creek, which does not contain tannery wastes. The river water continued to contain larger amounts of tannery wastes than normally throughout July 14, although the concentration began to be lowered gradually until by the afternoon of July 15, the river water was practically of normal quality.

He goes on with his conclusions:

1. That the Chemung River was receiving an unusual quantity of tannery wastes on July 13, 14 and 15, 1925.

2. That this high concentration of tannery wastes was due to the emptying of vats of this material into the Tioga River from a tannery at Blossburg, Pennsylvania.

3. That the Blossburg tannery is being remodeled into a silk mill, and therefore will not contribute tannery wastes in the future.

4. That a relatively small but fairly constant quantity of tannery wastes is emptied into the Cowanesque River at Elkland, Pennsylvania, from the tanneries of the Elkland Leather Company.

5. That the Elkland Leather Company is coöperating with the State authorities of Pennsylvania in studies upon the disposal of the tannery wastes, so that the concentration of the tannery wastes in the Cowanesque River probably will be much less in the future than at present.

6. That the concentration of tannery wastes in the Chemung River on July 13, 14 and 15, 1925, was sufficient to seriously handicap the filtration plant in producing a water of a satisfactory sanitary and physical quality at the time.

7. That the Elmira filtration plant as at present constructed cannot economically purify Chemung River water when the turbidity is more than approximately 200 parts per million.

We thought then that interstate pollution was a thing of the past. In December we were having a little color in the water from tannery wastes and I wrote on December 14 to Mr. Holmquist at Albany about the matter and he referred it to the Pennsylvania Department. I should like to ask your patience while I read just one more letter from the Pennsylvania Department:

I have just received your letter of December 8 relative to difficulties in the operation of Elmira water works alleged to be caused by tannery wastes.

So far as I know, the tannery waste vats at the abandoned tannery at Blossburg, are completely empty and I, therefore, do not think that could possibly have been the cause of trouble at Elmira.

In Pennsylvania there are two tanneries on streams tributary to the Chemung River. Both of these tanneries are parties to the agreement with the Sanitary Water Board, and I am making inquiry of them to ascertain if anything unusual occurred prior to or during the period November 29 to December 4.

You will be interested to know that the work of the Tannery Waste Disposal Committee of Pennsylvania is progressing upon a thorough and scientific basis.

The more we go into it, the more difficult the problem becomes. Nevertheless, we are optimistic of the outcome, but it will take time.

Then suddenly on January 12, after I had this report outlined, the color jumped from 15 to 25. In an effort to keep up the output, the alum dosage was increased from 0.91 to 1.37 then to 1.80 and we kept running until 4 a.m. on the 13th when the plant had to be shut down. I was notified later and telegraphed Mr. Holmquist so that he might be informed as to conditions. Late in the afternoon, we were able to resume operations on a moderate rate of flow and by the next day the color had dropped to 20 and we were able to handle enough during the twenty-four hours to keep up the supply. Then came the thaw at the end of the week and we had plenty of water to use from the creek reservoir and we stopped the use of the river.

More or less briefly that is the recent history of interstate stream pollution as it relates to one type of pollution in one community. It is a real menace and Elmira is extremely grateful that she has at hand a means for counteracting the possible contagion and disease which

might follow the use of water from which the tannery waste is not eliminated. The most encouraging and forward-looking part of the whole affair is this correspondence which I have read between the two State Departments of Health. We found our own New York State Department most efficient and most ready to assist at all times. It is a great pleasure to know we have them ready to assist at all times. As I said, we are running on storage now. We do not care what the river holds, but we hope it will be cleaned up very soon.

THE INSTALLATION OF METERS IN ERIE[1]

By D. W. Harper[2]

The Erie Water Department is an unusual organization. In fact, it is unique in the State of Pennsylvania, in that it is the only Water Department in the State, instituted and still operating under a special act of the Legislature. This legislation was enacted April 4th, 1867, and under its provisions, the Commissioners were to be appointed by the Judges of the Court of Common Pleas of Erie County.

Pursuant to this Act, the Judge appointed three Commissioners and the Commission commenced to function with energy. The City Council voted a bond issue of $675,000. A contract was then let by the Water Commissioners for the construction of a pumping plant, the installation of pumps and all necessary equipment for a station with a capacity of four million gallons daily (but the first year's pumpage averaged about 182,000 gallons per day). From this modest beginning, the department has grown to its present proportions and last year pumped an average of 22,216,418 gallons per day and with many days as high as 33,000,000 gallons. There are a number of manufacturing plants, each pumping for their own use, more water than the water department pumps. It has been the constant aim of the Commissioners not only to keep pace with the growth of the city but to keep in advance of such growth, realizing the importance to the city of a well ordered water department.

With the exception that the City Council must approve the rates, rules and regulations for the sale of water, the Water Commissioners have full authority and control of the water department.

For many years the intake and pumping facilities of the Department were adequate to take care of not only their immediate demand for water, but there were also ample excess facilities to provide for the normal growth of the city. During this period, there is no record of any discussion for the sale of water, other than on the flat rate

[1] Presented before the Central States Section meeting, October 9, 1925.

[2] Water Department, Erie, Pa.

basis. However, as industrial consumers began to use water in larger quantities it became apparent that those consumers should be metered. The manufacturers assented to this as an entirely reasonable and proper method and on March 12th, 1883, a schedule of meter rates was prepared, regularly submitted to City Council and approved by them. Reference to this meter rate, as approved, is interesting, in that it was at least a gesture in the direction of conserving water by providing that meters might be attached to any premises. It reads as follows:

> Meters may be attached to any premises, where city water is used, as the Commissioners shall direct, but in no case shall the charge be less than is required by the schedule of annual rates. In all cases, where the quantity of water used, as ascertained by the meter, exceeds in value the amount to which the premises are liable by the schedule of annual rates, said excess of water will be charged for at meter rates. When more than one meter is required on any premises, the cost of each meter after the first, together with the expense of setting the same and keeping it in repair, shall be borne by the owner of the property.

For reasons which are not important to discuss, at this time, the Commissioners felt that an application of this schedule to domestic consumers would not be satisfactory and the flat fixture rates were continued. From time to time there have been modifications of the schedule above referred to, but always with the same general result.

Again there was a long period of apparent satisfaction with the sale of water on this combination schedule of flat fixture rates for domestic consumers and metering for large consumers.

About fifteen years ago, however, due to the unusual growth of the city and especially the coming to Erie of very large manufacturing plants, which were large water users, the pumping facilities and intake pipe were taxed to capacity, and it became necessary to provide for increased capacity for the intake pipe and install larger and more modern pumping equipment. In addition to this, it became necessary to extend the intake pipe out into the lake and provide settling basins, filter plant and chemical treatment of the water. These last items are for sanitary reasons. These installations taxed the revenues of the Department severely and forcibly brought to the Commissioners' attention, the importance of the conservaton of water.

From the beginning the Commissioners were cognizant of the fact that there was considerable waste of water especially on the part of

domestic consumers and a system of house to house inspection was inaugurated in an effort to reduce this waste, but with only indifferent success. This waste still continues.

From time to time they earnestly discussed the question of putting all consumers on a meter basis—not only to eliminate the waste of water referred to above, but being convinced that to sell water other than by meter was manifestly unfair—unfair in the first instance to the Department, but even more unfair to the conservative user of water.

The larger economic phase of the proposition was constantly recurring to the Commissioners, i.e., obviously, the considerable waste of water, plus the rapid growth of the city, would soon call for an additional intake pipe and a new pumping station. The estimated cost of this improvement would be not less than $2,000,000. It was equally clear to the Commissioners that this large expenditure could be deferred for a number of years, if the waste, estimated at approximately 8,000,000 gallons per day, could be eliminated and the only way in which the Commissioners felt this could be accomplished, was by the installation of meters for all consumers.

The position of the Commissioners on this question was not based on theory, but upon the experience of cities all over the country, which had already gone through the same difficulty, with which Erie was confronted.

In the year 1918, the Commissioners took up actively the question of universal metering and employed a competent corps of engineers to make a rate investigation and set up a schedule of meter rates which their investigation would indicate was fair and proper for application in Erie. This investigation was accordingly made and a meter schedule was set up. This was duly submitted to the Council and after considerable discussion failed of approval by them.

We are quite free to say that, in our opinion, the failure of the Council to approve this was due entirely to their not being in close enough touch with the serious situation in which the Water Commissioners found themselves and also that they were influenced by the quite natural fear which has been present in every city all over the country, when meters were proposed, viz.: That the installation of meters would prevent the proper use of water as well as increase the charge to the public. That these fears are groundless is readily proven by a canvas of metered cities throughout the country.

For several years after 1918, the metering question lay dormant as

far as the general public was concerned, but it was a constant subject of discussion by the Water Commissioners. It could not be otherwise, as the daily pumping reports showed that the extreme capacity of the intake pipe, was being rapidly approached. The theoretical capacity of the intake is 40,000,000 gallons per twenty four hours, but under the most favorable conditions and for periods of ten and fifteen minutes only, the best it has been able to do is 37,000,000 gallons. During the extremely hot weather as well as the severely cold spells, the pumpage has run as high as 33,000,000 gallons per day. This leaves all too close a margin and has given the Commissioners much concern. Believing that either universal metering will have to be adopted or preparations made for the providing of an additional intake pipe and a new pumping station, they again approached the City Council in 1924 with a schedule of meter rates and urged that they take early action upon this very important subject.

The Council and Mayor gave the proposed schedule earnest consideration, but frankly stated that they did not feel that they were sufficiently familiar with all the elements entering into the problem to act intelligently or hurriedly so they have employed a rate expert to investigate the whole subject and report to them on his findings. This investigation is now under way and we have reason to believe that with the honest and earnest method of approach on the part of the Council, which is now being followed up, the Commissioners will have the coöperation and support of the Council in establishing a meter schedule. It seems unnecessary in a meeting like this to take up time to prove the wisdom of universal metering, but it nevertheless seems appropriate to cite a few examples in support of the contention of the Commissioners of Water Works in the City of Erie that the very best thing for the citizens themselves is that all consumers should be metered at as early a date as possible.

For example, the City of Grand Rapids, Michigan, makes the following comparative statement of water consumption before and after metering:

YEAR	POPULATION	NUMBER OF SERVICES	METERED	AVERAGE DAILY PUMPAGE
			per cent	*gallons*
1912	120,000	21121	53	15,833,000
1922	145,947	29018	100	15,250,000

Please observe that, with an increase in population of 26,000, there was a reduction in the daily average pumpage of about 600,000 gallons per day. This is a very fair demonstration of the soundness of the argument for meters.

Again, a more recent example,—in fact, one that is now under way: The City Manager of Wheeling, West Virginia, has provided us with some very remarkable figures in the way of reduction in pumpage, due to the setting of meters before the metering process has been one-half completed:

Daily pumpage, 1922,	21,823,000
Daily pumpage, 1925 (only 30 per cent metered)	13,600,000

A comprehensive survey of the State of Ohio has recently been made by the State Board of Health with respect to metering of water consumption. The conclusion of this report is to the effect that "for all cities and villages of Ohio, with service metered 100 per cent, the average daily consumption is ninety gallons per capita and that for cities and villages with no metered service, the average daily consumption is one hundred and seventy gallons per capita."

In passing, it is well to note that the per capita consumption in Erie for 1924 was one hundred and eighty four gallons.

The City of Chicago, after long discussion has, by a vote of two to one, authorized universal metering in that city. It was established that fully one half of the entire pumpage was being wasted and, with this fact before them, Chicago promptly decided upon metering.

We know of no city metering its water supply where the people do not use sufficient water or where, once metered, the city would consent to return to a flat rate system.

DISCUSSION

J. N. Chester:[3] Mr. President, the speaker was somewhat limited in his field. We have been engineers for ten or fifteen years for the Water Works Commissioners of Erie. We have also served the city. The Water Commissioners are a separate body by themselves. They are subject to action only on two questions. They can not change the rates without the Council's permission and they can not issue bonds except through the Council. Otherwise they are pretty much the czar in their own field. While we have been serving the

[3] Consulting Engineer, Pittsburgh, Pa.

Commissioners as engineers, we have also served the city as its engineers and have served two of the largest consumers of water as their engineers.

Mr. Harper told you they feared in enforcing the present meter schedule it would be unfair to the domestic consumer. That schedule is twenty cents a thousand gallon for the first twenty five and afterwards four cents a thousand gallon. Now, my way of putting that is,—I would enforce that schedule as to the domestic consumer and not let the manufacturer have water under that schedule. I would put him on a flat rate, because for a great many years this water department has not been able to deliver the water they are delivering to the manufacturers for what they have received. The domestic consumer has been carrying the burden of the factories.

When that schedule was passed, Detroit was selling water on the flat rate of two dollars and forty cents. The meters, when starting, gave it to consumers at three cents per one thousand gallons above a certain amount. Erie was charging thirty three and one-third per cent, if figuring from Detroit, more than Detroit. Today it costs Erie three and seven-tenths cents. It costs Jefferson City, Missouri, twelve cents, on operating expenses divided by consumption. The Water Works in Erie has been so prosperous that in fifteen years it has not issued a dollar's worth of bonds. It would have grown faster and better, but the burden has been carried on the wrong shoulders.

D. W. Harper:[2] I might say, in connection with Mr. Chester's remarks, there was only one bond issue in 1867. The Department has no debts except current bills. They made all extensions and improvements under the revenue of the department. Erie is an industrial community. As to what was in the minds of the Commissioners thirty years ago, I do not know. Mr. Gensheimer has been with the department long—only forty-eight years—he may remember. There was at that time a comparatively light rate to domestic consumers. It has been reduced since. The schedule was modified once or twice. We feel that the back bone and foundation of the City of Erie are the manufacturing interests. We feel that they should be given full credit and benefit for the large pumpage for which they are responsible. We also know, as Mr. Chester suggests, that the rate of the manufacturers is too low. We had, however, a number of conferences with them. Some object, but the general proposition of

the manufacturers is that they are fair and do not want water at less than cost. The Commissioners have always taken the position that there should be a differential between the rate of the large and small consumer and on that theory I think the old rates were made up. We are now attempting to work on a scientific basis. Mr. Bankson has said repeatedly and at conferences over metering that the flat rate should be for every one. That is not what we want. It is not correct, and I am making these remarks in support of our contention, our consumers are entitled to a differential. That can be supported. They do not want anything unreasonable. That is the situation at Erie on the question. We say at the present time we have the right to meter the city. We have a right to appeal to the small user. He does not use enough water.

H. F. Huy:[4] The policy of making low water rates is conducive to waste, to careless use of water that is not required. We had a striking experience at Niagara. The power company was continuing on the low rate, having power continuous. The power company was using such water as required, in the City of Niagara, without charge. As the power company grew they commenced to waste the water and used three million gallons a day. The contract was modified and they made different arrangements with the power company. The first month they continued doing that and they got a tremendous bill on the basis of two and a half million gallons a day consumption. Water was carried through transformers, one or two inch streams flowing through the day. The rates were slightly raised. The power company immediately took steps to eliminate the transformers. If you raise the price of water to a reasonable price that you should have, look at the point of view that you will have to quit square and then let the other man see whether it pays. If it costs you more money, he will make a profit. You will find the city that has low rates has larger consumption. When the rates are higher, their consumption drops down. Niagara Falls, prior to metering, used twenty two million gallons a day. The pumpage dropped to thirteen million gallons a day after metering.

[4] President, American Water Works Association. General Manager, Western New York Water Co., Buffalo, N. Y.

L. B. Harrison:[5] I want to mention the condition in Bay City. It has a population of about forty five thousand. Five years ago, the city was not all metered. The consumption was between seven and nine million gallons in twenty four hours, for forty five thousand population. Since the last five years we are supplying the city of Bay City with filtered water. With the city one hundred per cent metered, the consumption now is four million for forty five thousand. That is an additional fact of what metering does to the city.

D. W. Harper:[2] An even more startling example is the fact that in Erie we furnish the water free to the schools. A few years ago Mr. Gensheimer suggested we put meters in the schools, not to charge them, but to check them up. I have not the figures at hand—Mr. Gensheimer possibly has them in mind,—but there was a criminal waste of water in many of the schools. We rendered them statements calling attention to it and suggested they put in different kind of fixtures and make every effort to reduce the waste. Yet, we have no way of enforcing the reduction of waste, if service be continued to various schools without charge. We are a unique organization and we expect and are justified in expecting all parties to the game will play fair. Now we render a statement calling attention, from time to time, to what is being used. That is reducing the waste considerably. We furnish water free to the extent of something over fifty thousand dollars a year.

[5] Water Department, Bay City, Michigan.

OFFICE ADMINISTRATION OF CITY WATER DEPARTMENT[1]

By D. C. Grobbel[2]

Administration means the conducting of the business under certain restrictions imposed by a governing body or by rules and laws made by others outside of the immediate body controlling the business. The method of administrating the office of a city water department, therefore, depends upon the will or action of others than the administration itself. Further, such administration must cover a vast variety of actions, so that it is impossible to lay down any fixed rule for the purpose of setting a guide for those who form the administration body. Under ordinary circumstances, in a water works, the administration is charged with providing detailed plans for carrying out and enforcing the rules and resolutions of the governing body, whether these rules or resolutions concern the financing of the department, the planning of new structures, increasing production or changing distribution methods. Construction work may be planned, but to the office administration comes the problem of financing these. Methods of production and distribution may be adopted, but here again the office administration must determine the rate to be charged to the consumer for the water consumed, and thereby obtain the requisite funds to operate the plant.

It will be noted that office administration delves into every corner of a water department structure. To properly provide for the administration of all the functions imposed upon an administrator in conducting the business of a city water department, he must be provided with an organization of employes, which organization, as far as the qualification of personnel is concerned, differs for the different functions to be administered, but all responsible either directly or indirectly to the administrator. Again, the details of the various functional organizations depend, not only upon the size of the municipality, the local laws or usages, but also upon the thoroughness and

[1] Presented before the Central States Section meeting, October 10, 1925.

[2] Assistant Secretary, Board of Water Commissioners, Detroit, Mich.

efficiency with which the plant is to be administered. Needless to say, a small municipality would not need as large a force for the purpose of accounting as a larger municipality, nor would a slow-growing city need the same force of engineers, superintendents and foremen in its distribution would as the faster growing municipality. In the smaller water works, the chief executive can remain in personal touch with all details of office administration. His problems of construction, production and distribution are few in number and his list of consumers is numbered by the hundred, but as the department grows and his problems of construction increase, he must transfer much of the administrative work to others. The details with which he formerly concerned himself are crowded out by the stress of more important matters. He can not longer make a personal inspection of the customer accounts, the details in the construction work under way, nor note the many small needs of improvement that are constantly present in a water works plant. He is therefore compelled to allow other hands and other minds to carry out the policies of the department, enforce its rules, attend to the details of construction, arrange the financial affairs of the department and deal with the public.

The relations of the office administration are therefore manifold, but may be roughly classified as departmental relations and public relations. Departmental relations are those that bear upon the construction, production and operation of the department. Here office administration must exercise its greatest effort to obtain efficiency and thoroughness. Construction must be planned to produce the greatest results at a minimum outlay of funds and at the same time be of such enduring character that replacements need not be made except at long intervals. Nor can the construction be of such nature that will prove unprofitable or profitable only after a long time, during which time the interest charges on the amount of money invested would for a great number of years off-set any profit that might be made.

In this connection, it must not be forgotten that it is, unless otherwise provided by law and usage, incumbent upon the office administration to provide the plans for the financing of the different construction projects. It is the office administration which determines whether the cost shall be borne through earnings of the department, or whether the department's credit shall be used for this purpose. And the office administration is frequently called upon to determine the nature of the bonds to be issued. However, whether such

financing is determined by law, either state or municipal, the office administration is frequently in position from its knowledge of the records of the department and its earning powers to assist the public authorities in their work and be a means of keeping the bonded indebtedness of the department at a minimum.

Operation is part of the departmental relation and is most important from the office administration standpoint. Any interruption of operation is certain to bring down upon the heads of the office administration the wrath of an outraged public—be the interruption ever so brief. Therefore, does the office administration make every effort to secure adequate funds and efficient labor that there may be no failure in the water supply of the municipality. Nor must these funds be spent lavishly—the office administration has its eye continuously glued to the page of records which shows the cost of each gallon or million gallons of water produced or distributed. Any deviation from what is thought to be the proper cost figure is run down and if the excessive cost is caused by negligence or inefficiency, it is the office administration that must devise the cure. If on the contrary, the costs are driven upward by the natural causes over which the operating force has no control, the office administration is compelled to provide means to meet the increase, either by providing more efficient methods of operation or adjusting the rates to provide a greater revenue.

Office administration is more obvious in its relations to the general public or the water consumer. While office administration works behind the scenes in its departmental undertakings, its work with the consumer or the general public is done in view of every one. It is to the office administration that application is made for pipe lines, services and meters. Complaints of low pressure or lack of water come to the same body. Payment for water or other charges are made to it. In fact, as far as the general public is concerned, they know very little of the department, except through their intercourse with the office administrative body. To the public the administration is the department and the administration is held responsible for all short comings that the department may have, for all mistakes that the department may make.

It is therefore necessary that the office administration must present its best side to the public. Fair in its dealings, courteous in its treatment, forebearing under abuse are necessary attributes for success in its intercourse with the public. It is, however, to be

noticed that in this intercourse with the public, the rules of the department are also to be interpreted fairly, so that neither the department nor the consumer suffers. The relation of office administration to the public is mostly concerned with the securing of a proper return for the service rendered by the department and it is well for the office administration to bear in mind the viewpoint of the consumer when making any adjustment of the rate structure. Although the department may have a monopoly of the service in a particular municipality, it certainly does not follow that the charges be based upon this monopoly but rather upon a fair estimate of the needs of the department for operation and maintenance, sinking fund, interest and a fair allowance for the ordinary betterments.

Bearing the above in mind, the department will be able to sell itself to the public and again, although the department may have the monopoly in the community, it still needs to make friends of the consumer and the public. This friendship is necessary for the purpose of financing the department by bond issues, for the purpose of creating a favorable attitude among the citizens and the officers of the community and for the purpose of placing the intercourse between the consumer and the office administration on an amicable basis.

No specific methods of office administration have been presented, since its activities, to a very great extent, depend upon the laws and usages of the different municipalities or localities. Moreover, office administration changes more frequently in its attitude toward historic rules than any other division of a water department. In doing so, the office administration is following, or possibly at times, anticipating the public mind—where once the operation of a water department by a municipality was deemed revolutionary and looked upon as an enterprise to be conducted by private capital, now this same operation is considered a municipal governmental function, similar to such other functions as the fire department, the tax assessors or the police. Again, the rapid development of cities and their suburbs in recent years, and the attendant enlargement of the commercial and industrial life have made it necessary for the office administration to plan many additions for the department—change its method of accounting and billing, its plan of rates and financing.

This is more evident in the larger cities, as may be witnessed in Detroit—where in the past five years, it has been necessary to construct nine hundred and ten miles of pipe and change its method of making assessments for this pipe, three times. New ways of handling

suburban pipe extension had to be developed, and additional costs of production in the shape of filtering the water had to be absorbed. A new rate was established, changing from the minimum with a flat rate to a modern three-step rate and service charge. Payments which had heretofore only been made at the Main Office were arranged to be made at branch banks without cost to the department or the consumer. Where the department had only made a service tap, it now lays the service to the lot line and the day is not far distant when this service will be brought into the building.

All of the above changes were made without dislocating any operations of the department. However, the work of the office administration is not by any means finished, for, but a few days ago, a new meter reading and customer accounting system was adopted, by which it is hoped to give better service to the consumer and reduce the cost of the department.

As quite a number of the members of the Central States Section are familiar with the present Detroit system of three meter reading districts and its methods of billing and collecting, it might be interesting to them to know that under the new scheme there will be thirty six reading districts and every other day in the month will be a final payment day. Further, the new scheme will bring the reading date within seven days of the bill delivery date, instead of an average of six weeks, as heretofore.

Incidental to the above, the scheme provides a method of internal audit of receipts, a better control on delinquents and a larger output of bills at a less cost, per account, the latter no small item when it is realized that Detroit has approximately 202,000 meters in service.

As previously stated, no specific methods of office administration have been presented in this paper. However, it is hoped that this paper might provoke a discussion of office administration action as practiced by water departments in the Central States. Such discussion should prove not only interesting but also highly instructive.

DISCUSSION

J. N. Chester:[3] You contemplate carrying your service pipes into the building. Carrying it back fifty feet from the street, who will own the service after it crosses the property line?

[3] Consulting Engineer, Pittsburgh, Pa.

D. C. Grobbel:[2] That is a good question, Mr. Chester. I think that will be determined by the charter of the City of Detroit.

J. N. Chester:[3] The charter cannot change the land laws. Anything on the real estate goes with the real estate.

D. C. Grobbel:[2] Not necessarily so. We are not handling the service with capital. We charge a man forty dollars to lay a pipe from the main. We make the ditch and lay the pipe on the ordinary street. We do not charge for the lead or for the ditch, but for the permit to put that in. However, the question is, should it belong to our capital investment? The Courts will unquestionably say it is a capital investment.

J. N. Chester:[3] The other courts did not sustain that.

H. F. Huy:[4] In answer to Mr. Chester's question—we have a number of pipe lines owned by the water company on private property. Previous to that we made a contract that they are attached to the realty of the property and the water company has the right to remove the same. Another feature provides for all meters on private property at all times. When a house is sold, that is covered again, when the contract is originally entered into. You could cover that situation if you chose to lay pipes on private property.

J. N. Chester:[3] What value is that service to the water company, even though it has the right to remove it?

H. F. Huy:[4] As a part of business production—revenue to your property.

J. N. Chester:[3] Take the situation where you will. In the case of mains across private property, if you have an agreement that the pipe is yours, you have an easement across the place. If you file your agreement at the Court House you put an encumbrance on that man's property. This is all right and we advise our clients to do so. We do it ourselves, where we are the owners. We will not lay an inch of pipe on property unless it is recorded at the Court House.

[4] President, American Water Works Association. General Manager, Western New York Water Co., Buffalo, N. Y.

H. F. Huy:[4] It is a question of law whether it is necessary to record an easement. If the physical evidence is there, is it of use? In other words, you can not claim an exemption that a man has no right because you did not have it on record. If it is physically observed that it is there, that is just as good as putting it in the Court House.

J. N. Chester:[3] When a man comes and buys a house and lot, the seller of the property is not going to say: "There is an easement on here" if he can help it. It is under ground and he can not see it. If he buys it, everything is in. The meter is in evidence. Take the laws of the State of Pennsylvania, they would say that the meter is the company's, but not that the service pipe or the main is the property of the company.

H. F. Huy:[4] The evidence is that that pipe is in the ground. He sees the evidence of the pipe line.

D. C. Grobbel:[2] In case the local laws provide that the water department shall still be the owners of pipe lines, service, etc. it belongs to the water department.

J. N. Chester:[3] No sir, the local laws can not over-ride the government land laws.

D. C. Grobbel:[2] You will find in Michigan the water department generally owns the pipe under the local laws. I do not believe, as far as Michigan is concerned, it would be affected.

A Member: If there is a man living on the north side of the street does that property pay as much for service as the man on the south side of the street, if the first has ten feet of service and pays $40, while the other has sixty feet?

J. N. Chester:[3] In the City of Pittsburgh we pay for everything that goes to the curb line or inside. The laws of the State of Pennsylvania are that the city makes the consumer pay for everything they do, unless the Public Service Commission says, when it is owned by a private company, that they must make the tap, pay for the permit, carry it in the curb line and own and maintain it. We have certain

small municipalities and they sell water for so much and do so and so. They do not think how much the department exacts from that consumer before furnishing him, how much of the capital charge is paid by the consumer.

A Member from Warren, Ohio: In our city the owner pays for all service and that includes tapping. The city taps and is paid $2.50 for that. The service in that connection belongs to the property owner and is controlled by the city. Lately they passed an ordinance requiring their leading pipe on to properties, piping all the way in to the meter. The original contract under the old water company, before the city took away the plant franchise, was that all service should be led to the curb. In later years we found there was much steel pipe put in between the curb and the meter and there was so much leakage that they passed this new ordinance and they lead the pipe in to the meter. There is another condition along the line in which we are speaking. When the city took hold of the plant on January 1, 1921, they bought from the local company their own water department. At that time all of the water pipes in the street did not belong to them. During a few years preceding that time, a great many property owners laid cast iron pipes in the street. This the city did not buy and the company had no right to sell. They are confronted with a difficulty with these real estate owners. They come to us and want us to purchase the pipe in the street. To whom does the pipe in the street belong?

ADDITIONS TO THE EVANSTON, ILLINOIS FILTER PLANT[1]

By Paul Hansen[2]

The prevalence of typhoid fever in Evanston prior to 1913, the fact that adequate treatment of the water supply with hypochlorite of lime for sterilization imparted an objectionable taste to the water, and the fact that the water supply at times was highly turbid, led to the installation of a filter plant in 1913 and 1914 as the only rational and economical solution of the local water works problem.

The original plant was designed by George W. Fuller and Langdon Pearse, and was installed under their direction. The plant and its construction were described in The Journal of the American Water Works Association for 1915 by Mr. Pearse.

The original plant had a nominal capacity of 12,000,000 gallons per twenty-four hours and comprised the following elements:

(1) Chemical preparation and feed devices, including means for the application of alum and hypochlorite of lime. Liquid chlorine and apparatus for its application was later installed.
(2) A mixing and reaction chamber with a nominal retention period of twenty minutes.
(3) Two coagulating basins with a total nominal retention period of one hour and forty minutes.
(4) Six mechanical filter units, each with a nominal capacity of 2,000,000 gallons.
(5) A covered clear water storage reservoir with a capacity of approximately 2,000,000 gallons.

At one end of the group of filters is a head house for chemical preparation and feed devices, chemical storage, laboratories, offices, toilets and lockers. This same head house is adequate for serving the enlarged plant.

The arrangement of the original plant was somewhat unusual, as a result primarily of limited land available and certain restriction with reference to architectural effects to harmonize with the buildings

[1] Presented before the joint sessions of the Illinois, Wisconsin and Iowa Sections, March 17, 1925.

[2] Of Pearse, Greeley & Hansen, Consulting Engineers, Chicago, Illinois.

of the Northwestern University. These restrictions were imposed on account of the fact that the land was acquired from the Northwestern University. At the time the original plant was installed the importance of a design that would permit of ready expansion was fully appreciated and the arrangement adopted was such as to permit of a maximum utilization of the land available, in connection with the construction of future additions.

In designing the original plant there was recognition of a tendency to large and variable consumption and the capacity adopted was deemed adequate to meet requirements until at least 1930. Notwithstanding the foresight with which the plant was designed, the consumption of water in Evanston increased much more rapidly than anticipated. Even the metering of all services failed to cut down the consumption materially. This is explained by the fact that most of the residents of Evanston have more or less extensive lawns and have sufficient means to use all of the water they desire. This condition is reflected in the range of consumption shown in table 1, and also by the fact that the largest consumption occurs on warm dry days in summer.

The design of the original plant was very carefully worked out and the best commentary on this is the fact that it was not necessary to change any essential detail in designing the new additions. The new filters units are all precisely like the old ones.

In this connection it is interesting to note that bids were taken on a pipe underdrain system and a concrete underdrain system with brass strainer plates of a design exactly like the old ones. Contrary to expectations a lower price was obtained on the concrete system than on the pipe system. The concrete system was also preferred by the the water works management, although there had been considerable trouble after the installation of the original system due to breakage of bronze bolts for holding down the strainer plates. This difficulty was found to be due to imperfections in the metal and was completely overcome by substituting monel metal for bronze.

The only important modification made in the new work was the use of reinforced concrete slab construction in the place of groined arch construction for the coverings over the clear water reservoir and the coagulating basins. Even this change was not essential, but was deemed advisable on account of the greater familiarity of contractors with the slab construction and the assurance of obtaining better prices.

The new additions permitted some readjustments to facilitate operation, principal among which was the shortening of the coagulant feed line to the reaction chamber and coagulating basins, the rearrangement of the reaction chamber and coagulating basins so as to permit their complete control from the end of the basins immediately adjoining the filter operating room and the substitution of sluice gates for stop planks throughout.

The nominal capacity of the enlarged plant is 24,000,000 gallons, or double the capacity of the old plant. For periods of a few days the filters may operate at the rate of 36,000,000 gallons per twenty-four hours. If the rate of consumption were uniform this quantity could actually be delivered to the consumers, but the rate of consumption is not uniform, and, therefore, clear water storage is necessary to neutralize the hourly fluctuations and to provide a certain reserve for washing the filters and a further reserve for meeting fire emergency. The limitation of land did not permit obtaining as much clear water storage as would be desirable. In fact, it was only possible to increase the clear water storage by 667,000 gallons making a total of 2,667,000 gallons, whereas eight to nine million gallons would have been desirable.

It became of interest, therefore, to determine what actual maximum daily consumption the new filter plant can meet. Accordingly a curve was plotted, shown in figure 1, which represents the composite hourly fluctuations in consumption of a number of typical days of large consumption. If the filters are operated at the maximum rate consistent with preventing the overflow of the filtered water reservoir, we estimate that, with the available clear water storage, the maximum actual yield of the filter plant in a single day is about 31,000,000 gallons.

To indicate how long the plant will fulfill the requirements of the cities of Evanston and Wilmette, we have studied the probable future water consumption. Figure 2 shows the probable future population growth of Evanston and Wilmette. We have indicated both a maximum and a minimum. For estimates we have used a mean rate. The consumption records of the plant were carefully examined with the result that the per capita consumptions given in table 1 may be regarded as applicable to the future.

Combining these per capita figures with population figures for the various years there was developed figure 3 giving the total average daily consumption for the maximum month, maximum day and

maximum hour for various years. In the operation of the filter plant the maximum day will be the controlling factor. As already indicated the maximum actual daily output of the filter plant will

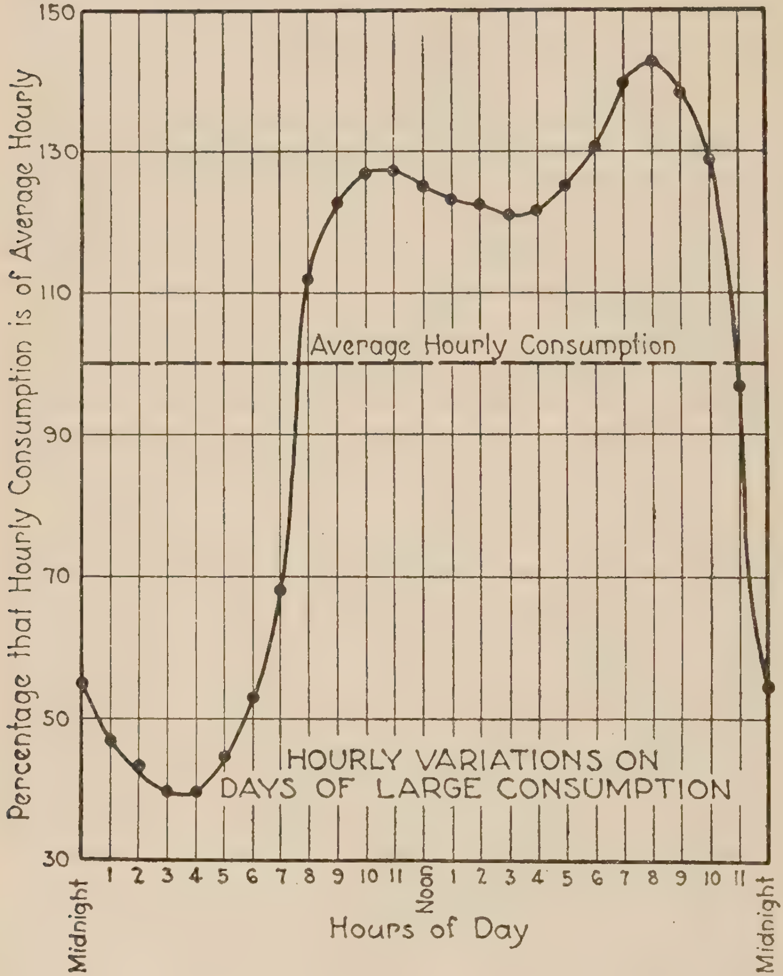


FIG. 1

be in the neighborhood of 31,000,000 gallons. This capacity, according to our estimates, should prove adequate until the year 1952 when the population of Evanston and Wilmette will be very close to 109,000.

The plant is very flexible and easy to control. The coagulating basins may be used in series, in parallel, together or independently, with or without the reaction chamber. The filters have all been equipped with new rate controllers of an improved type devised and

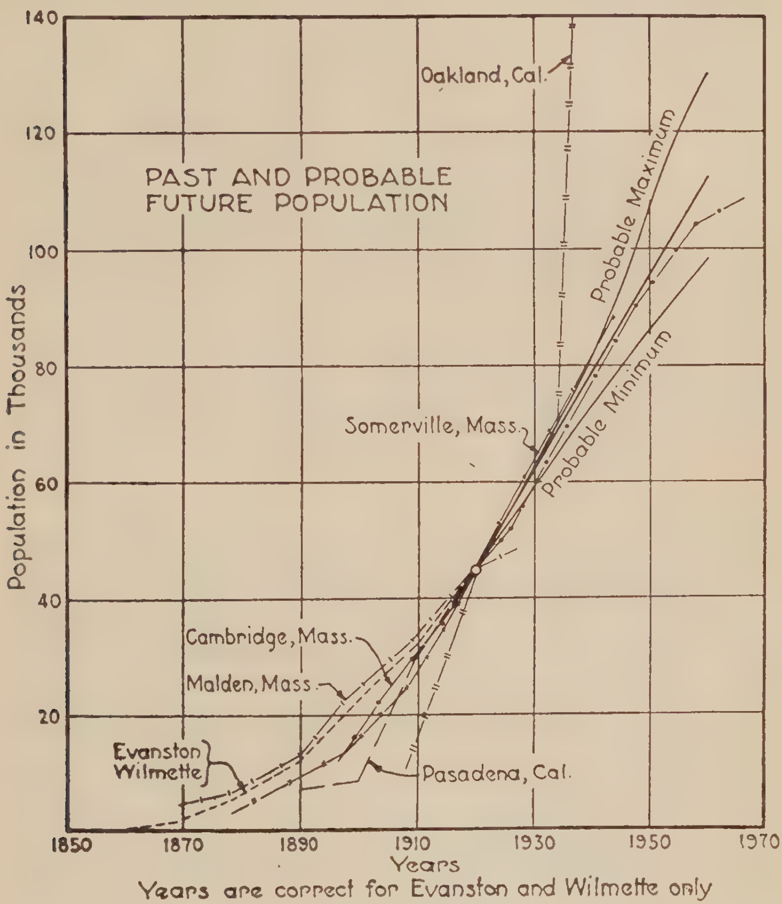


FIG. 2

manufactured by the Builders Iron Foundry. The various connections to the filters are controlled by hydraulically operated valves, operated by hand-levers on operating stands, which stands are placed on the operating floor in front of each filter. The flow of water to the filter plant from the low-lift pumps is measured by a

TABLE 1

Per capita consumptions used as basis of design for new additions

Condition	Gallons per capita per day
Average per year	160
Average per maximum month	240
Maximum day	320
Maximum hour	430

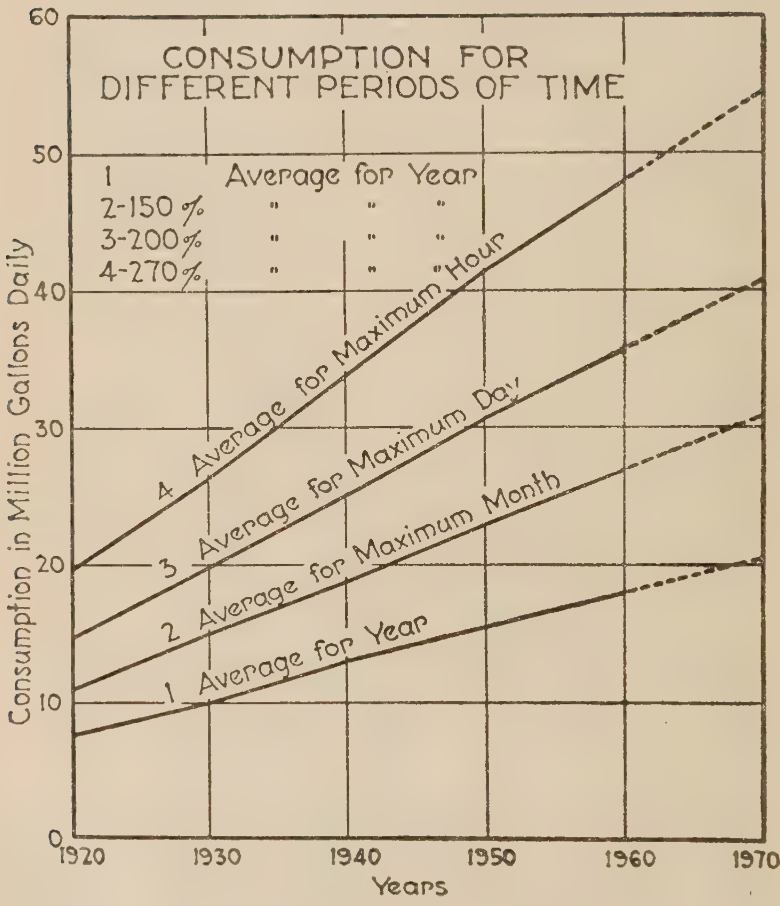


FIG. 3

FIG. 4. EXTERIOR OF EVANSTON FILTER PLANT

FIG. 5. OPERATING ROOM, EVANSTON FILTER PLANT

Venturi meter, and the discharge into the distribution system is also measured by a Venturi meter.

The high-lift pumping equipment has been augmented by a new Allis-Chalmers cross compound crank and fly-wheel condensing pumping engine with nominal capacity of 18,000,000 gallons per twenty-four hours. Some interesting problems of underpinning and construction had to be worked out in connection with the preparation of suitable space for this new pump in the existing pumping station

The actual structural details of the filter plant involve nothing exceptionally new or novel. In exposing the walls which receive the thrust of the groined arches of the old plant, special care had to be observed to remove water pressure and to provide for a construction which would resist the tendency of these walls to be pushed out by the pressure of water and the thrust of the arches.

The general appearance of the exterior of the plant is shown in figure 4 and a view of the enlarged operating room is given in figure 5.

The additions to the filter plant were designed by and built under the supervision of Pearse, Greeley and Hansen. H. D. White was Resident Engineer. The general contractor was W. J. Newman Company of Chicago, and the filter contractor was the Norwood Engineering Company of Florence, Mass. W. S. Blanchard was Commissioner of Public Works of Evanston and had general responsibility for the improvement. G. A. Wadsworth, Superintendent of Water and W. N. Wood, Superintendent of Filtration, were closely in touch with the work and offered many helpful practical suggestions in connection with the design.

PLACARDING PUBLIC WATER SUPPLIES ALONG TOURIST HIGHWAYS[1]

By Earle L. Waterman[2]

During the past summer a new sign has greeted the travelers along Michigan highways. It carries a word of warning concerning one of the most dangerous perils of the road. It warns the traveler against the use of unsafe drinking water. The sign is 14 by 27 inches and the black lettering on a gray background reads "Caution—Drink only Water Approved by the Michigan Department of Health." These signs are conspicuously posted at five mile intervals along the trunk highways.

Another type of sign is to be placed along the highways in Minnesota which will indicate to the tourist or other traveler that the public water supply of the town about to be entered is safe. This sign, 18 by 24 inches in size, will announce in deep blue letters on a yellow background—"Public Water Supply Approved by the Minnesota State Board of Health." The signs will be placed on state trunk highways by the State Highway Commission and on the county roads by the county engineers. Permission to erect such signs is given only under certain conditions which must be agreed to by the municipality. Briefly the municipality must agree to have its water supply investigated at least once a year and to make such changes, improvements or repairs to the water supply system from time to time as may be necessary to maintain it in a satisfactory condition. They agree to notify the State Board of Health promptly of an accident which might affect the sanitary quality of the water and also to offer no objection to the removal of the signs in case the water supply at any time is found to be below the standard of purity required by the State Board of Health.

This project of placarding public water supplies along tourist highways is a further development in the plan of marking sources of safe drinking water along these highways. The plan was origi-

[1] Presented before the Iowa Section meeting, December 4, 1925.

[2] Professor of Sanitary Engineering, University of Iowa, Iowa City, Iowa.

nated by the Ohio State Department of Health about two years ago and has been very carefully worked out in that state. It is an attempt to answer the question of the motorist—"Where may safe drinking water be obtained along the public highways?" The construction of hundreds of miles of improved roads and the use of these roads by many thousands of motorists has made this question of safe drinking water along the highways a very important one from a public health standpoint. Most municipal water supplies have been developed and are maintained so that they meet the standards set up by the state departments of health.

The resident of a city which has a satisfactory public water supply has acquired a feeling of safety concerning the water which is furnished to him in his home and in fact pays very little attention to it. He knows that the whole matter of water supply is in the hands of competent men and that the quality is carefully watched by local and state health officials. Under these circumstances it is not strange that the average citizen has no experience and no knowledge which will enable him to judge whether or not the waters which he finds along the highways in the open country are safe to drink. The use of water in his home has perhaps led him to believe that any water that is clear, cool and pleasant to the taste is a safe drinking water and he drinks such waters wherever he can find them.

The problem then is to designate by definite, descriptive placards those sources of semi-public water supplies along the highways which are safe. The general plan is to make a sanitary survey of each source of supply along the road. If the survey shows that the supply is properly located, properly developed, and properly maintained then samples of water are taken for laboratory examination. The results of this examination are considered with the report of the sanitary survey and a decision made as to whether the source of supply will furnish a safe drinking water. If the data indicate that the supply is satisfactory the owner of the property on which the supply is located is asked to sign an agreement with the state department of health permitting the placing of signs and agreeing not to object to the removal of such signs whenever the state department finds that the supply is no longer safe. Usually a small sign is attached to the pump or faucet and a larger sign erected in front of the property and others a few hundred feet from it along the highway on either side. This plan of marking enables the motorist to find the supplies of safe drinking water without difficulty.

Definite programs for marking the safe sources of water supply along the principal highways are being carried out in Connecticut, Delaware, Indiana, Illinois, Kentucky, Michigan, Minnesota, Missouri, Ohio, Pennsylvania, and Washington. Sanitary surveys and bacteriological examinations of roadside water supplies are being made in Arizona, Maine, New Mexico, Rhode Island and Virginia, but no signs have been erected in these states. The water supplies at tourist camps are supervised by the state health departments in Maryland, Texas and Utah. This summary indicates that the problem is receiving attention in many states and it seems probable that it will eventually be recognized as an essential phase of state sanitary engineering throughout the United States.

The work on highway water supplies in Pennsylvania is unique in one respect. The laboratory examination of samples is made in a field water laboratory. Specially designed bodies are mounted on truck chassis. The car is equipped with all the apparatus necessary for a complete bacteriological examination. Samples are collected during the day and the examination started within six hours of the time that the sample was taken. In addition to the routine roadside samples it is the practice in Pennsylvania to take at least two samples from the public supply of each municipality through which the field laboratory passes. The use of a field laboratory eliminates the uncertainties in results which arise when samples have to be shipped some distance to a central laboratory. The experience with a field water laboratory during the summer of 1924 was so satisfactory that two units were used in the work during the summer of 1925. During the last season these units covered 2700 miles of highways and 2360 supplies were examined. This figure includes re-examination on 410 supplies which were approved in 1924.

Minnesota is the first state to undertake the posting of safe public water supplies, although Pennsylvania makes the same examinations of this type of supplies as are made on the semi-public highway supplies. The use of "Caution" sign warning travelers in Michigan to drink only water approved by the state department of health seems to indicate that signs will soon be used in that state to mark the locations of approved public water supplies.

The placarding of safe public water supplies along tourist highways has several features which commend it. First, it will inform the travelling public of the location of approved water supplies;

second, it will advertise the municipality as one which is furnishing a safe water within its boundaries; third, it will be an incentive to laggard public officials to see to it that their public water supply is up to required standards. It is a project which may well receive the hearty support of all water-works men.

SEASONAL VARIATIONS IN THE AMMONIA AND NITRATE CONTENT OF LAKE WATERS[1]

By B. P. Domogalla,[2] E. B. Fred and[3] W. H. Peterson[3]

In a previous paper (1) the marked seasonal variation of the ammonia and nitrate content of lake waters was reported. During the winter it was found that the lower strata show a decided increase in the free ammonia and in the nitrate nitrogen. This is followed in midsummer and in early fall by a disappearance of the nitrates and another rise in the ammonia content. The experiments recorded here were undertaken with the view of studying the possible factors which cause these well defined changes in the forms of nitrogen in lake water. The preliminary data indicated that these fluctuations are due to the seasonal variations in the activity of certain groups of microörganisms.

That ammonia and nitrate formation as well as nitrate reduction in fresh and salt waters are the result of the activity of certain bacteria has been pointed out by various investigators. Thomsen (2) found nitrifying bacteria with morphology very much like those found in soils active in sea water near Kiel at temperatures that ranged from 1 to 55°C. Russell, Jones, and Bahrt (3) found nitrifying bacteria in Nebraska soils having the same range of activity as those found in sea water, from 5 to 55°C., with their maximum at 35°C. Lipman (4) reported the absence of nitrification in sea water. Minder (5) in a study of the bacterial flora of different lakes noticed that the ammonia content of waters was proportional to the bacterial count while the nitrate content was just the reverse. Drew (6) found denitrifying bacterial flora in the tropical ocean waters which he believed caused the precipitation of calcium carbonate. Kellerman and Smith (7) as well as Lipman (8) noticed that denitrification takes place in

[1] This work was supported by the special research fund of the University of Wisconsin and by the Engineering Department of the City of Madison, Wisconsin.

[2] The Wisconsin Geological and Natural History Survey and the Engineering Department of the City of Madison, Wisconsin.

[3] The University of Wisconsin, Madison, Wisconsin.

ocean waters. Smith (9) in a further study of the bacteria of ocean waters and mud found a large number of ammonifiers present. Netschaff (10) noticed a seasonal variation in the denitrification activity in the Newa River in Russia. The process was found to be active in spring and fall, and at a temperature as low as 0°C.

EXPERIMENTAL

Lakes studied. Seven inland lakes of Wisconsin and Lake Michigan have been included in this study. A brief description of these lakes has been given in an earlier report (11). A more detailed description of the Wisconsin lakes and their plant and animal life has been given in reports of the Wisconsin Geological and Natural History Survey (12).

Lake Mendota and Lake Monona were studied more closely than the other lakes. Lake Mendota is 6 miles long, 4 miles wide, and has a maximum depth of 84 feet. Lake Monona is 4 miles long, $2\frac{1}{2}$ miles wide, and has a maximum depth of 74 feet. Both lakes are hard water lakes and contain an abundant growth of plankton. Due to their depth these lakes become thermally stratified. From late June to early October the water is separated into three distinct strata. The upper layer is warm and kept in circulation by the wind. It is in this upper layer that the majority of the plankton organisms are found. The bottom layer consists of cool water which has little or no circulation. It is here that the greatest proportion of the decomposition of the organic matter takes place together with a depletion of oxygen. Between these two strata there is a transition zone in which the conditions change from those of the warm water above to the cool water below.

Samples. Two to 5 liter surface, bottom, and mud samples were taken from all of the lakes studied. The bottom samples in each case were taken about 2 meters above the mud. In the case of Lake Mendota and Lake Monona 5, 10, 15, and 20-meter depth samples were taken in the middle of the lake at times when these lakes were well stratified. Samples were taken each week or more frequently when marked changes in the chemical or bacteriological activity was noticed. The dissolved oxygen samples were collected in special 250 cc. bottles. The bacteriological samples were collected at the same time in large sterilized Pyrex test tubes by the use of a special sampler (13). The tables in this report indicate the average analyses for each month.

TABLE 1

Bacteriological and chemical analysis of the waters of Lake Mendota

DATE	DEPTH	BACTERIA PER CUBIC CENTIMETER*	NITRATE REDUCTION IN DAYS		NH_3–N	NO_2–N	NITRIFICATION IN DAYS		DISSOLVED OXYGEN
			11°C.	28°C.			11°C.	28°C.	
1923	*meters*				*mgm. per cu. M.*	*mgm. per cu. M.*			*grams per cu. M.*
July 24	1	800		7	96	23			
	20	1600		3	420	40			
1924									
March 12	1	1300			180	11		36	13.2
	20	1800			748	60		27	5.3
April 7	1	2300		20	144	83		25	13.1
	20	2300		20	144	83		25	4.2
July	1	1500	20	18	73	25		33	8.9
	20	1700	13	10	392	53		38	1.5
October	1	2500	10	8	66	15	42	39	8.8
	20	2000	8	6	640	16			0.3
November	1	1900	12	11	110	14	37	34	9.1
	20	2000	12	11	112	15	37	34	9.1
December	1	2200	25	21	120	16	34	32	9.2
1925									
January	1	2600	24	22	128	17.3	37	33	13.24
	20	2850	21	20	160	19.7	27	24	7.66
February	1	3800	23	20	142	24.0	36	32	12.73
	20	2300	17	15	324	47.4	28	22	6.04
March	1	1200	19	16	147	62.7	32	29	12.15
	20	1600	12	15	556	121.2	18	14	3.51
April	1	1300	19	16	190	70.3	25	20	9.29
	20	1300	19	16	192	72.3	25	20	9.30
May	1	1100	15	13	184	61.0	24	19	10.61
	20	1000	10	8	211	74.5	25	19	9.45
June	1	1500	13	11	173	45.6	26	22	7.95
	20	1300	9	6	285	68.7	28	23	4.58

TABLE 1—*Continued*

DATE	DEPTH	BACTERIA PER CUBIC CENTIMETER	NITRATE REDUCTION IN DAYS		NH_3–N	NO_3–N	NITRIFICATION IN DAYS		DISSOLVED OXYGEN
			11°C.	28°C.			11°C.	28°C.	
1925	*meters*				*mgm. per cu. M.*	*mgm. per cu. M.*			*grams per cu. M.*
July	1	2000	12	8	72	18.0	32	27	8.10
	20	2500	8	5	460	32.0	34	31	0.0
August	1	1800	10	7	73	19.5	33	28	8.30
	20	2300	7	5	568	21.0	37	33	0.0
September	1	1400	15	12	84	19.0	28	24	7.60
	20	1900	9	8	697	12.5	33	28	0.00
October	turnover	2200	15	14	240	12.0	25	23	8.83
November	1	2100	15	15	188	17.9	26	23	9.05
	20	2500	18	16	210	18.4	29	25	8.98

* Bacteria grown on Nutrose Agar at 28°C.

Methods of analysis. The different forms of nitrogen were determined on fresh water according to the procedures given by the American Public Health Association (14). The dissolved oxygen samples were collected in special bottles and analyzed according to the Winkler method as given in the Wisconsin Survey Bulletin (15).

The total number of bacteria present in lake water was determined by plate counts, on Nutrose agar and beef peptone agar. The rate of nitrate reduction was measured by the number of days required to completely destroy the nitrates in 10 cc. of Giltay's solution containing 0.01 per cent KNO_3. The rate of nitrification was measured by the time required to oxidize to nitrates the ammonia in 50 cc. of 0.1 per cent $(NH_4)_2SO_4$ medium after inoculating with 50 cc. of water.

DISCUSSION OF RESULTS

1. Chemical and bacteriological variations in the waters of Lake Mendota

The forms of nitrogen listed in table 1 and figures 1 and 2 are the main sources of supply for the plankton, and other forms of life in the lake waters. The chief sources of this nitrogen are from inflowing

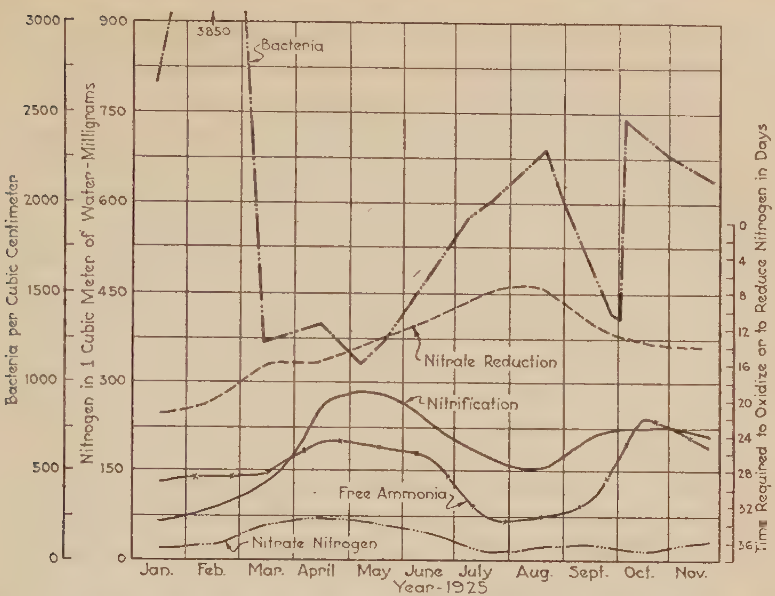


FIG. 1. NUMBER AND ACTIVITY OF CERTAIN GROUPS OF BACTERIA AND THE AMMONIA AND NITRATE CONTENT OF THE SURFACE WATERS OF LAKE MENDOTA IN 1925

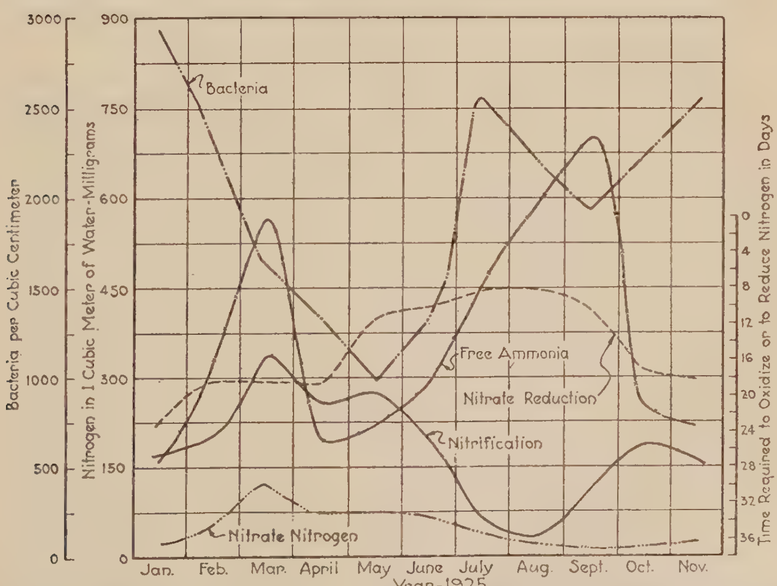


FIG. 2. NUMBER AND ACTIVITY OF CERTAIN GROUPS OF BACTERIA AND THE AMMONIA AND NITRATE CONTENT OF THE BOTTOM WATERS OF LAKE MENDOTA IN 1925

waters, rain, and decomposition of organic material contained in the mud and debris at the bottom of the lake. Besides free ammonia various forms of soluble organic nitrogen are formed from the decomposition of the bottom debris as mentioned in a previous paper (16). Most of the debris in the lake settles out along the bottom about a block away from the shore, and covers an area from the 10-meter zone to the 23-meter zone. The debris gradually changes to a loose black mud with about 85 per cent moisture content. In December before the decomposition becomes very active the total nitrogen in the mud averages about 0.11 per cent on the dry basis: in other words there is about 680,000 kgm. of potential nitrogen in the 620,000,000 kgm. of mud. The analyses of the lake waters show that but a small portion of this nitrogen tied up in this mud is changed into soluble forms of nitrogen.

As soon as the soluble nitrogen increases in the bottom strata it begins to spread upward toward the surface. The marked changes appear first and are more pronounced in the lower layer than in the surface water. During the spring and fall turnovers, the soluble nitrogen content is uniform. As soon as stratification begins, these forms of nitrogen in the bottom strata again exceed those in the surface water. An understanding of these changes can be better gained by considering the variations which occur in the bottom water of Lake Mendota.

Beginning with the fall turnover there is little change in the soluble nitrogen until mid-winter. Sudden and enormous increases occur in February and March. By the time the spring turnover occurs in April a total increase of about 300 per cent in free ammonia and about 200 per cent in nitrate nitrogen are observed in the bottom strata. The increases are observed first in the bottom water and later at various depths until finally they are noticed at the surface. During the time that the ammonia and nitrates increase the oxygen decreases in the lower strata, but does not disappear entirely, as is the case during the summer months. Sufficient oxygen is present during the winter months for the oxidation of ammonia to nitrates.

In spring after the turnover takes place the lake becomes uniform throughout and the bottom and surface samples contain the same quantity of ammonia, nitrates, and oxygen. When stratification again takes place in early summer, the nitrates decrease and the ammonia again increases in the lower layer of water. In midsummer the oxygen also disappears rapidly from the bottom and the

reduction of nitrates is most active. The analyses of the lake waters for the last four years have shown that the increase in the ammonia content in the bottom waters during the winter months reaches a higher concentration than during the midsummer stratification. In 1925, however, the ammonia content in the lower strata did not rise to as high a level in winter as in former years due to the fact that the time for the winter stratification was about a month shorter than the average.

At a time when the soluble forms of nitrogen were high in Mendota, samples were collected from various places and depths of the lake,

TABLE 2

The distribution of ammonia and nitrate nitrogen in Lake Mendota water
Calculated for 1 cubic meter of water

STATION	SURFACE			10 METRES			18–20 METERS		
	2/1/24	3/3/24	3/11/25	2/1/24	3/3/24	3/11/25	2/1/24	3/3/24	3/11/25
	Ammonia nitrogen								
	mgm.	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*
I	104.0	180.0	152.0	120.0	204.0	196.0	176.0	392.0	472.0
II	120.0	196.0	164.0	128.0	216.0	280.0	200.0	640.0	544.0
III	120.0	193.0	180.0	144.0	236.0	236.0	208.0	528.0	528.0
IV	104.0	176.0	160.0	112.0	200.0	212.0	168.0	384.0	500.0
	Nitrate nitrogen								
I	27.8	62.5	55.5	55.5	76.9	65.7	68.9	119.0	96.2
II	31.2	87.9	55.8	61.7	90.9	73.5	78.4	178.5	125.0
III	34.8	78.1	67.0	63.3	87.7	70.4	87.0	166.6	111.1
IV	29.7	66.6	61.6	58.8	96.1	68.5	80.0	125.0	104.2

table 2, as well as from the inflowing springs. The forms of nitrogen are distributed rather uniformly over the lake as shown by the analyses of the waters taken from different stations which are about one mile from one another. The results given in table 2 also indicate that as soon as there is an accumulation of ammonia and nitrate nitrogen in the bottom waters there is a gradual upward diffusion of these forms of nitrogen. Merrill and Warner's springs that flow into Lake Mendota have a very high nitrate content, about 2800 mgm. NO_3 nitrogen per cubic meter of water. Due to the fact that they contribute only about 1 cu.m. of water per hour, they have little influence on the total volume of Lake Mendota, which is 478,370,000

cu.m. In February 1924 a special study was made of the extent to which Merrill and Warner's springs affect the nitrate content of Lake Mendota. The results showed that the spring water dilutes rapidly with the lake water, and at a distance of about 600 feet from the springs the nitrate content of the lake is about the same as that in the middle of the lake. In a previous paper (1) the analyses of other waters flowing into Lake Mendota were reported and the study at that time showed that all the ammonia and nitrate nitrogen flowing into Lake Mendota could account for only a small fraction of the rise in the nitrogen content that occurs in the lake during the winter months. These great increases in ammonia and nitrate nitrogen indicate that there are great biological activities going on in the lake even in the winter months. Some idea of the importance of these processes may be gathered from the fact that every 2 mgm. rise in the nitrate content means that about a ton of nitrates have been added to the lake waters.

Ammonification. Table 1 and figures 1 and 2 show the variations in the number of bacteria in both the top and bottom of Lake Mendota in 1925. In general the results agree with those reported in an earlier paper (17); namely, that the total number of bacteria in Lake Mendota water is variable and is not due to insufficient food. The occurrence and the activity of ammonifying bacteria in lake water were studied by means of plate counts. A comparison was made of the total number of microörganisms on sodium caseinate or Nutrose agar and beef peptone agar. The average difference between the count on the two different kinds of media was about 20 to 40 per cent higher on the Nutrose. The development of a large number of bacteria on the beef peptone agar was taken as indicative of the presence of ammonifiers. At times when the ammonia content in the lake water showed a marked rise, the approximate number of ammonifiers present was determined by means of Dunham's medium. A series of dilutions of the lake water was made and tubes of Dunham's medium inoculated. The tubes were tested daily for ammonia and peptone. The approximate number of ammonifiers grown on Dunham's medium compared very closely with the total number of bacteria grown on beef peptone agar. Figures 1 and 2 show the relationship that exists between the total number of bacteria and the ammonia content. In general, an increase in the number of bacteria was followed by an increase in the ammonia content of the water. This relationship is more noticeable in the bottom water

than in the surface water which is influenced at times by the abundant growth of plankton, as well as the inflowing and outflowing waters.

Nitrification. From the curves of figures 1 and 2 it will be seen that an increase in the rate of nitrification follows a rise in the ammonia content during the winter months. Due to the lack of oxygen in the bottom waters during the summer and fall months a rise in the ammonia in the bottom water was not followed by a rise in the nitrifying activity. As long as oxygen was present in the cold lower strata, nitrification proceeded. As shown in table 1 the rate of nitrification at 11°C. was almost as rapid as at 28°C.—about three to five days slower at 11°C. than at 28°C.

A special study was made at various times to see if both groups of nitrifiers were present in these lake waters. Tests were made for those forms which oxidize the ammonia to nitrites and the forms which oxidize nitrites to nitrates. The presence or absence of ammonia was determined with Nessler's reagent; the nitrites determined with Trommsdorf's reagent, and the nitrates with diphenylamin. Both forms were found present at all times and grew well at either 11°C. or 28°C., and hence indicate that nitrification may take place in the cold bottom lake waters as long as there is oxygen present. Such has been found to be the case in February and March when the waters are cold and the nitrate content increases rapidly in the bottom strata.

Nitrate Reduction. As shown in the figures, nitrate reduction occurred throughout the year and at all depths. At certain seasons this reducing activity was greater than at other times. Late in winter when the nitrate content was high or in midsummer and fall when the dissolved oxygen content was low, the nitrate reduction was found to be most active. In 1925 the nitrate reduction for Lake Mendota ranged from seven to twenty-two days for the surface water, and five to twenty days for the bottom water. Occasionally when the nitrate reduction was most active, dilution counts were made. About 500 to 1000 bacteria were found per cubic centimeter of water. In summer when the lake was well stratified the nitrate reduction was far more active in the bottom water than at the surface. The low temperatures prevailing at the bottom of the lake do not retard the nitrate reduction to any great extent. As shown in the tables the rate of reduction at 11°C. was only from two to four days slower than at 28°C.

2. *Chemical and bacteriological variations of the waters of Lake Monona*

Since March, 1925 the top and bottom waters of Lake Monona have been analyzed as frequently as those of Lake Mendota. The

TABLE 3

Bacteriological and chemical analysis of the waters of Lake Monona

DATE	DEPTH	BACTERIA PER CUBIC CENTIMETER	NITRATE REDUCTION IN DAYS		NH_3-N	NO_3-N	NITRIFICATION IN DAYS		DISSOLVED OXYGEN
			11°C.	28°C.			11°C.	28°C.	
1925	*meters*				*mgm. per cu. M.*	*mgm. per cu. M.*			*grams per cu. M.*
March	1	2900	10	6	168	73.5	30	18	10.6
	20	3000	10	6	668	192.3	20	16	2.9
April	1	3600	14	10	536	100.0	18	14	9.1
	20	3300	12	8	584	120.0	20	18	8.8
May	1	2500	14	9	522	99.5	20	16	8.2
	20	3200	10	6	668	145.0	18	14	6.0
June	1	2700	11	8	499	82.0	21	16	6.1
	20	3200	8	5	752	136.0	21	17	0.5
July	1	3300	9	5	476	52.0	24	20	7.7
	20	3400	6	3	1012	20.0	28	25	0.0
August	1	3200	10	6	248	49.0	22	19	8.5
	20	3600	6	4	1256	23.0	31	28	0.0
September	1	2800	13	8	283	68.0	22	18	7.5
	20	2600	10	6	1295	19.0	29	25	0.0
October	turnover	3000	12	9	350	81	23	19	9.1
November	1	2900	13	10	415	99.0	22	18	10.5
	20	3200	14	11	485	105.0	20	17	9.5
December	1	3000	12	10	438	120.0	20	17	11.0
	20	3300	12	9	525	131.0	18	16	9.0

average monthly analyses are given in table 3 and some of these are plotted in figures 3 and 4. Throughout the entire season of 1925,

the total number of bacteria in Lake Monona was about 1000 to 2000 higher than in Lake Mendota. The majority of these organisms are active ammonifiers and grow well on Nutrose or beef peptone agar. The relationship between the number of bacteria and the ammonia content of the water is brought out in figures 3 and 4. Especially in the bottom waters of Lake Monona a rise or drop in the total number of bacteria is followed by a corresponding rise or drop in the ammonia content. As soon as the summer stratification

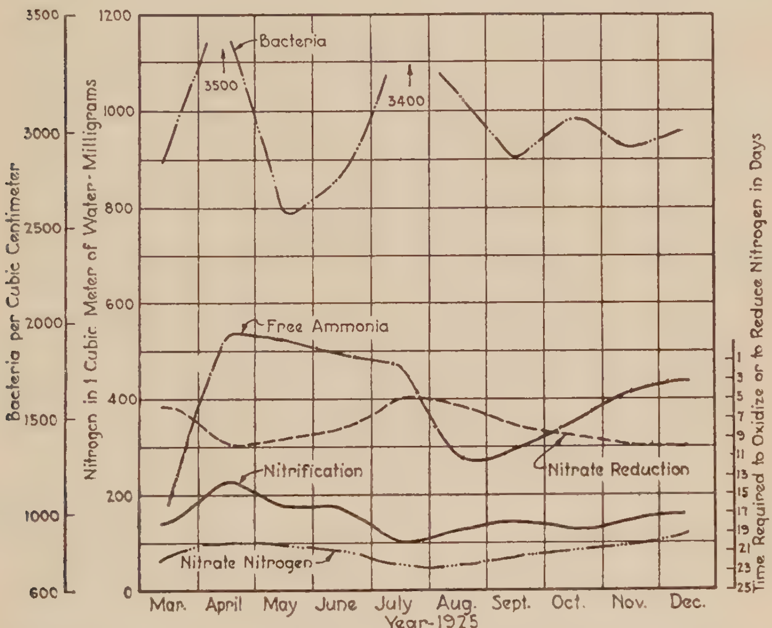


Fig. 3. Number and Activity of Certain Groups of Bacteria and the Ammonia and Nitrate Content of the Surface Waters of Lake Monona in 1925

began, the ammonia increased and the nitrate content decreased rapidly in the lower strata. The ammonia content in the lower layer of water rose as high as 1295 mgm. in Lake Monona in comparison to 697 mgm. per cubic meter in Lake Mendota before the fall turnover took place. The rate of nitrate reduction in Lake Monona was three to six days faster than that found during the corresponding months in Lake Mendota. During the spring and summer months when the nitrate reduction was most rapid in Lake Monona and Lake

Mendota, the nitrate content in the bottom water of Lake Monona dropped from 120 to 19 mgm. per cubic meter whereas in Lake Mendota the drop was from 72 to 12 mgm. per cubic meter. At the same time when this rapid nitrate reduction was going on in the Monona bottom waters, the dissolved oxygen disappeared more rapidly than in Lake Mendota. In the surface waters the dissolved oxygen also made a drop in both of these lakes as the season advanced from spring to summer, but this decrease was chiefly due to the lower solubility

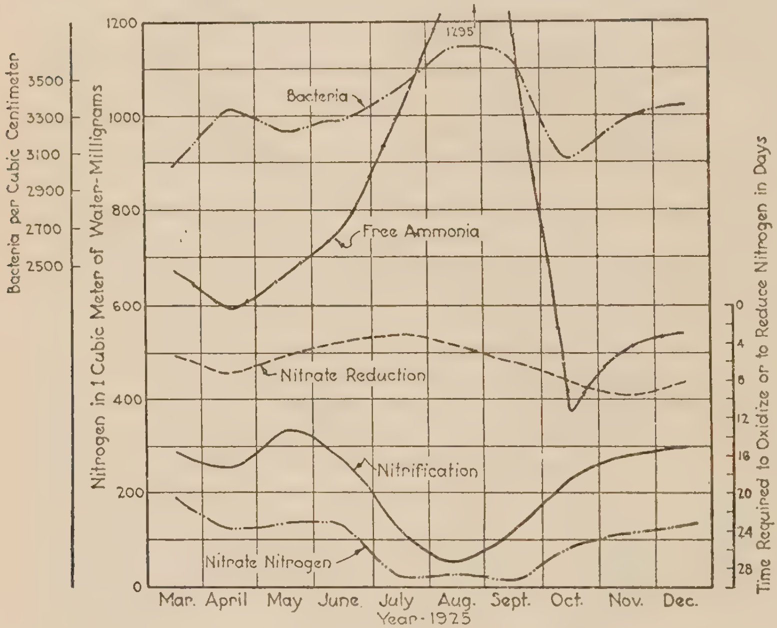


FIG. 4. NUMBER AND ACTIVITY OF CERTAIN GROUPS OF BACTERIA AND THE AMMONIA AND NITRATE CONTENT OF THE BOTTOM WATERS OF LAKE MONONA IN 1925

of the oxygen at higher temperatures. On the other hand, during the summer the temperatures of the bottom waters of Lake Monona as well as Lake Mendota remained rather high, around 16 to 18°C. Early in spring when the ammonia showed a marked rise in both the top and bottom waters of Lake Monona in the presence of a substantial amount of dissolved oxygen, the rate of nitrification became more active than during the other seasons of the year. At all times the rate of nitrification was from five to ten days faster in Lake Monona

than in the water of Lake Mendota. It is interesting to note that nitrification is so active in all of these lakes regardless of the presence of organic matter.

3. Bacteriological and chemical variations in the waters of lakes other than Lakes Mendota and Monona

Green Lake is the deepest inland lake of Wisconsin, having a maximum depth of 223 feet. This lake, like Lake Mendota, is a hard-water lake. Green Lake has regularly shown a higher bacterial count than Lake Mendota, about 1500 more per cubic centimeter of water, table 4. The rate of nitrate reduction was much slower in Green Lake, about sixteen days being required in comparison to only eight days for the time of nitrate reduction in Lake Mendota during the same month. In the fall the ammonia was lower, whereas the nitrate content was noticeably higher in Green Lake bottom waters than in the lower strata of Lake Mendota. In the Green Lake mud taken at 67 meters, like the mud of Lake Mendota, the ammonia was higher and the nitrate content was lower than that found in the waters about 2 meters above the mud. During the summer and fall the oxygen in the lower strata of Green Lake did not disappear entirely as was the case in Lakes Mendota and Monona. Consequently the rate of nitrification was rather active in Green Lake at a depth of 65 meters. During the fall months the average time of nitrification for the bottom waters of Green Lake was twenty days in comparison to thirty-nine days for Lake Mendota bottom water. In the spring, the rate of reduction was about twice as fast as that found to be the case in the fall months.

Devils Lake is a shallow, soft-water lake in Wisconsin. Although the total number of bacteria was considerably lower than that of Mendota, the rate of nitrate reduction was about as fast as that found in Lake Mendota. However, the rate of nitrification and the ammonia and nitrate content were considerably lower than that found in Lake Mendota.

Lake Michigan was the largest fresh water lake included in these studies. The bacterial count and the rate of nitrate reduction was lower than that found in most of the other lakes studied. The rate of nitrification was about the same as that found in Lake Mendota.

Lakes Waubesa, Kegonsa, and Wingra are a part of the chain of lakes to which Lake Mendota and Lake Monona belong. The waters of Mendota and Lake Wingra empty into lake Monona thence into

TABLE 4

Bacteriological and chemical content of lake waters

SAMPLE	DATE	DEPTH	BACTERIA PER CUBIC CENTIMETER*	NITRATE REDUCTION IN DAYS		NH_3-N	NO_3-N	NITRIFICATION IN DAYS		DISSOLVED OXYGEN
				11°C.	28°C.			11°C.	28°C.	
		meters				*mgm. per cu. M.*	*mgm. per cu. M.*			*grams per cu. M.*
Green Lake	10/11/24	1	4200	18	16	36	18.2		31	8.9
	10/11/24	65	3500	14	10	168	153.8		20	3.7
	10/11/24	67	3900	7	6					
	11/ 8/24	1	3800	20	18	40	18.3	36	29	9.2
	11/ 8/24	65	2200	10	10	184	159.6	24	19	3.9
	2/28/25	1	7800	14	10	69	23.9	38	30	12.7
	2/28/25	65	6600	8	4	206	57.7	28	20	9.2
	4/29/25	1	4900	10	8	90	27.8	35	28	9.1
	4/29/25	65	4800	11	9	95	29.5	36	28	9.1
	12/22/25	1	3900	24	20	72	30.5	30	25	
Devils Lake	11/28/24	1	500	11	11	37	14.2	47	45	10.2
	11/28/24	12	500	8	8	38	15.0	38	34	9.5
	2/ 4/25	1	300	23	20	53	16.7	42	39	13.3
	2/ 4/25	12	400	18	14	64	19.5	34	30	13.1
	5/ 4/25	1	700	10	8	57	17.5	38	35	10.8
	9/20/25	1	600	12	9	10	12.0	45	40	8.9
	12/ 6/25	1	300	13	12	41	18.5			10.1
Lake Michigan	2/ 8/25	1	800	24	20	102	50.0	34	30	12.7
	2/ 8/25	70	1000	20	14	164	83.0	28	25	6.2
	2/ 8/25	72	2200	13	10	204	79.0	25	20	
Lake Waubesa	3/16/25	1	2000	14	10	152	101.6	30	18	
	3/16/25	10	2600	10	6	508	156.2	24	17	
	5/ 2/25	1	2000	13	10	304	100.0	18	15	10.5
	6/ 8/25	0	2100	11	8	200	56.0	19	16	8.8
	7/24/25	0	2900	7	4	148	37.0	23	20	8.5
	7/24/25	8	3000	5	2	208	31.0	26	22	7.4
	8/19/25	0	2300	12	7	88	22.0	23	19	8.0
	8/19/25	8	2500	7	5	268	20.0			7.8
	9/17/25	0	1900	12	9	89	35.0	24	20	8.0
	9/17/25	8	2100	10	7	205	30.0			7.0
	10/ 5/25	0	3200	9	5	60	36.0	20	17	9.3

TABLE 4—*Continued*

SAMPLE	DATE	DEPTH	BACTERIA PER CUBIC CENTIMETER*	NITRATE REDUCTION IN DAYS		NH_3–N	NO_3–N	NITRIFICATION IN DAYS		DISSOLVED OXYGEN
				11°C.	28°C.			11°C.	28°C.	
		meters				*mgm. per cu. M.*	*mgm. per cu. M.*			*grams per cu. M.*
Lake Kegonsa	5/ 2/25	0	2300	13	6	232	110.0	19	16	9.4
	6/ 8/25	0	2600	10	7	168	50.0	19	15	8.6
	7/25/25	0	2400	6	3	96	39.0	21	19	8.6
	7/25/25	6	4000	3	1	168	35.0	23	21	7.5
	8/20/25	0	2300	8	4	100	28.0	22	17	8.4
	8/20/25	8	2300	4	2	180	25.0			7.8
	9/17/25	0	2100	9	5	95	35.0	21	16	7.8
	9/17/25	7	1600	8	5	120	29.0			7.1
	10/ 5/25	0	4100	6	3	95	30.0	19	15	8.8
Lake Wingra	5/ 8/25	0	900			108	150.0	17	14	8.0
	6/ 8/25	0	1200	14	10	100	196.0	18	16	7.8
	7/27/25	0	700	10	8	172	85.0	24	21	8.2
	7/27/25	5	700	9	7	180	82.0	22	20	7.6
	8/20/25	0	1500	13	11	64	55.0	25	20	8.5
	9/17/25	0	1000	15	12	75	51.0	27	21	8.5
	10/5/25	0	1500	13	8	62	39.0	20	17	8.0

* Bacteria grown on nutrose agar at 28°C.

Lake Waubesa and finally into Lake Kegonsa. The bacterial count as well as the ammonia content of Lakes Waubesa, Kegonsa, and Wingra was markedly lower than that found during the corresponding months in Lakes Mendota or Monona. In spring when the nitrate content was high, the rate of nitrification was two to five days faster in Lake Wingra than in any of the other lakes in that chain. As the season advanced from spring to fall the rate of nitrate reduction was more rapid in Lake Kegonsa than in the other lakes of that chain, due chiefly to the presence of a great number of nitrate reducers in the drainage waters that empty into this lake.

Nitrate reducing bacteria occurring in the different lakes were isolated and their morphology noted. By means of twelve enrichment transfers in Giltay's media and finally from Giltay's agar pure colonies of denitrifiers were obtained. These bacteria isolated from

the waters from various lakes were found to be of the same general type, viz., short rods with rounded ends, and stained solidly with gentian violet and carbol fuchsin. These organisms appear to have the same characteristics as some of those isolated from sea water by Drew (6), Kellermann and Smith (7), and Lipman (8). Under anaerobic conditions, they made a profuse growth.

SUMMARY

The seasonal fluctuations in the ammonia, nitrate, and oxygen content of lake waters was found to be due almost entirely to a seasonal variation in the bacterial flora of the lakes studied. These variations were noted in the surface waters, but were more marked in the bottom waters.

The ammonia and nitrate content reach a maximum about March, at a time when the ammonifiers and nitrifiers are most active. A marked rise in ammonification in the lower strata, especially in the mud, precedes the rise in nitrification which is most active about 2 meters above the mud. The increases are observed first in the bottom waters and later at various depths until finally they are noticed at the surface.

During mid-summer and fall the ammonia content increases as well as the activity of the ammonifiers in the lower strata. At the same time the oxygen disappears rapidly and nitrate reduction becomes more active than otherwise with the disappearance of the nitrates.

Ammonification, nitrification, and nitrate reduction often occur at the same time, yet at certain seasons of the year one of these processes is more marked than the others in the same lake.

Variations occur in the different lakes studied with respect to the time and predominant type of chemical change that takes place; that is, in winter when there is a marked rise in the ammonia and nitrate content, the ammonifiers and nitrifiers were found to be most active, and in summer when the ammonia increases and the nitrate and oxygen content decrease rapidly the ammonifiers and nitrate reducers are most predominant.

The rate of nitrate reduction and the rate of nitrification is about as active at 11°C. as at 28°C.

REFERENCES

(1) Domogalla, B. P., Juday, C., and Peterson, W. H. 1925 Jour. Biol. Chem., lxiii, 269.

(2) Thomsen, P. 1908 Thesis, Univ. of Kiel.

(3) Russel, J. C., Jones, E. G., and Bahrt, G. M. 1925 Soil Sci. xix, 381

(4) Lipman, C. B. 1922 Science lvi, 501.

(5) Minder, L. 1920 Archiv. f. Hydrobiologie xii, 122.

(6) Drew, G. H. 1914 Papers from the Tortugas Laboratory, Carnegie Inst., Wash, v, 9.

(7) Kellermann, K., and Smith, N. R. 1914 Jour. Washington Acad. of Sciences, v, 400.

(8) Lipman, C. B. 1924 Papers from the Dept. of Marine Biology, Carnegie Inst., Wash., xix, 181.

(9) Smith, N. R. 1924 Jour. Washington Acad. of Sciences, xiv, 323.

(10) Netschaff, N. 1925. Cent. Bakt. Abt. 2, lxv, 86.

(11) Juday, C. 1914 Wis. Geol. and Nat. Hist. Survey, Bull. 27.

(12) Birge, E. A., and Juday, C. 1922 Wis. Geol. and Nat. Hist. Survey, Bull. 64.

(13) Wilson, F. C. 1920 Jour. Bacteriology, v, 103.

(14) Standard Methods for the Examination of Water and Sewage. Amer. Pub. Health Assoc., New York, 5th Edition, 1923, 13–19.

(15) Birge, E. A., and Juday, C. 1911 Wis. Geol. and Nat. Hist. Survey, Bull. 22, 5–21.

(16) Peterson, W. H., Fred, E. B., and Domogalla, B. P. 1925 Jour. Biol. Chem. lxiii, 287.

(17) Fred, E. B., Wilson, F. C., and Davenport, A. 1924 Ecology v, 322.

RESIDUAL CHLORINE AND THE BACTERIAL CONTENT OF SWIMMING POOLS[1]

By E. B. Buchanan[2] and R. G. Perkins[3]

In the summer of 1923 a survey was conducted of 16 Cleveland swimming pools and it was found that there was no uniformity in methods of purification nor in the quantities of hypochlorite used when pools were chlorinated directly with hypochlorite. During the following fall and winter, conferences were held with various pool operators and steps were taken to unify the methods of treatment. Finally the simple method of daily use of chlorinated lime added at the rate of 0.5 part per million was adopted by all the pools.

In order to prove to the operators that such a system was efficient, bacteriological samples were taken hourly from 2 of the pools under consideration and examined for colon group organisms and total count.

It was found during the tests that there was at first a rapid decrease in bacterial count, and a total elimination of colon group organisms in 10 cc. portions of the water, even with bathers in the pool, but that later in the day there was a gradual increase in total count, not paralleled by increase of colon organisms (table 1) which indicated that the amount of available chlorine present late in the day was insufficient to destroy the more resistant types of bacteria.

This plan was continued throughout the year and the weekly analyses tabulated for several similar pools which were closely following instructions of the Health Division. A study of these figures revealed the fact that during the year there were several constant periods during which samples showed a decided increase in counts over the general average. These high points coincided with vacation periods for school children who were in the majority in using these pools, so that apparently more chlorine was used up in combining

[1] From the Laboratories of the Cleveland Division of Health and the Department of Hygiene of Western Reserve University.

[2] Chemist in Division of Health, Cleveland, Ohio.

[3] Professor of Hygiene and Preventive Medicine, Western Reserve University School of Medicine, Cleveland, Ohio.

with the dirt introduced into the pool and less left for attacking the bacteria (see table 2).

This confirmed the previous conclusion that chlorination once a day was sufficient to remove colon group organisms, but might be insufficient to maintain a low count where there were so many bathers that the residual chlorine was completely utilized. In order to find

TABLE 1

	POOL A		POOL B	
	Count per cubic centimeter	Colon group	Count per cubic centimeter	Colon group
Before chlorination	5,000	Present in 10 cc.	2,300	Present in 10 cc.
1 hour after	5	None		
2 hours after	2	None	5	None
3 hours after	1	None		
5 hours after	3	None	5	None
7 hours after	7	None	1,000	None
9 hours after	13	None		
12 hours after	400	None		
	100 bathers—pool chlorinated 2 hours before opening		90 bathers—pool chlorinated 2 hours before opening	

TABLE 2

	NUMBER OF SAMPLES	AVERAGE AGAR COUNT PER CUBIC CENTIMETER	NUMBER SAMPLES WITH COLON GROUP
School year	34	283	None
Summer vacation	25	787	None
Winter vacation	9	1,414	1

what amount of chlorine would suffice to eliminate resistant strains as well as colon group organisms, tests were made at 3 pools involving various types of Cleveland bathers.

These tests were arranged so as to start with 0.5 p.p.m. available chlorine early in the day, and to make simultaneous bacteriological and residual chlorine tests at intervals throughout the day. These results are recorded in table 3.

These tests showed that there was a point somewhere between 0.1 and 0.2 p.p.m. chlorine at which the count would tend to increase, and since the rate at which chlorine is utilized is dependent largely upon the number of bathers, it was evident that chlorination once a day was insufficient to maintain a pool (having large numbers of bathers) in a satisfactory condition.

TABLE 3

TIME INTERVAL	TEST A			TEST B			TEST C		
	Colon group	Count	Chlorine	Colon group	Count	Chlorine	Colon group	Count	Chlorine
			p.p.m.			p.p.m.			(1 pound added) p.p.m.
Start	10 cc.	3,500	None	10 cc.	5.000	None	None	10,000	None
15 minutes	None	12	0.6	None	2	0.5+	None	10	0.4
1 hour	.None	1	0.5+						
2 hours	None	1	0.5	None	2	0.5			
3 hours	None	1	0.5				None	50	0.15
4 hours	None	0	0.5	None	5	0.4			
									(½ pound added)
5 hours	None	0	0.5−				None	2	0.35
6 hours	None	0	0.4	None	2	0.3			
7 hours							None	50	0.15
8 hours				None	50	0.07			
9 hours							None	100	0.15
11 hours							None	300	0.06
15 hours	None	1	0.1						
18 hours				None	10,000	0.03	None	5,000	0.00
	Bathers using pool, 40—chlorinated 20 minutes before using			Bathers, 90—chlorinated 1 hour before using			Bathers, 103—chlorinated 1 hour before using		

To prove that it would be possible to maintain a pool having many bathers in a satisfactory manner by maintaining over 0.2 p.p.m., a test was conducted at a pool similar to the ones mentioned and it was found that the lower limit (0.2 p.p.m.) was reached about 4 p.m., so the operator was advised to add again one-half as much chlorinated lime in the evening as he had added in the morning, thus maintaining a +0.2 p.p.m. at all times. This was done daily and

samples taken over a period of eleven months. These figures are to be compared with three months' samples before maintaining in excess of 0.2 p.p.m. chlorine (see table 4).

This improvement was so remarkable that it was decided to provide each person in charge of a pool with an outfit enabling them to test their own pool for residual chlorine. In the event of their finding chlorine in excess of 0.2 p.p.m. they could be assured that their pool would be in a satisfactory bacteriological condition. At the same time it would make it possible for the Division of Health inspector to test a pool on the premises, thus eliminating the necessity of examination at the laboratory except in the case of pools showing less than 0.2 p.p.m. available chlorine.

The outfit shown in figure 1 is composed of a wooden block about 4 by 5 by 7 inches with three equally spaced holes bored through it just large enough to take standard 50 cc. color comparison tubes (no. 1). A thin strip of metal screwed to the bottom, overlaps the

TABLE 4

	NUMBER OF SAMPLE	AVERAGE COUNT	NUMBER OF SAMPLES WITH COLON GROUP
Before 0.2 p.p.m.	19	4,220	1
After +0.2 p.p.m.	30	27	0

upper edge of each hole sufficiently to prevent complete passage of the tube. The whole block is mounted on side plates so as to be steady at an angle of about 60°, permitting the reflection of light up through the tubes while the outfit stands on the table. A bottle of ortho tolidin and a dropper (0.5 cc. capacity) are provided with each outfit, the latter being kept in a small hole in the left hand corner of the top of the block (no. 4). Each tube is provided with a rubber stopper through which has been cut a hole of sufficient size to hold a $\frac{5}{8}$-inch test tube or flat bottomed vial (no. 2). This tube must be long enough to permit the bottom to be slightly below the surface of the contained solution. Small rubber stoppers (no. 3) are suspended from a movable wire bridge to be used to keep dust from collecting in the visibility tubes. When in use this bridge drops down out of the way. A test tube brush is mounted under the inclined surface of the block and may be used to remove dust from the visibility tubes (no. 5). The outside tubes are filled with copper sulphate,

potassium dichromate standard color comparison solutions equivalent to 0.2 and 0.5 p.p.m. chlorine. This solution will remain unchanged for at least nine months. The stopper is then inserted so that the $\frac{5}{8}$-inch tube extends slightly into the solution. The center tube is used to make the test; it is filled to the 50 cc. mark with swimming pool water, a dropper full (0.5 cc.) of ortho tolidin is added, the tube stoppered with one of the tube stoppers and the mixture shaken. This is then inserted into the central hole in the block and, after one minute, examined.

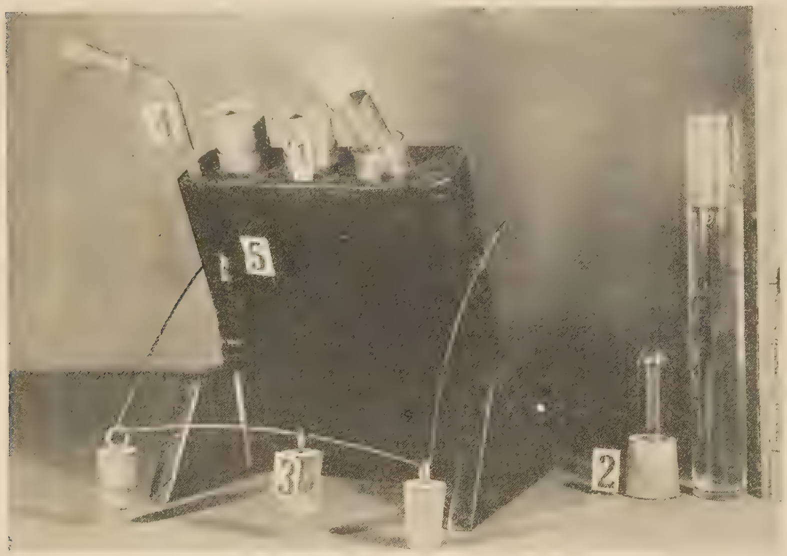


Fig. 1. Chlorine Determination Outfit

If the color is more intense than the lighter tube, the operator knows his pool is all right; in the event it is lighter, it is advisable to add one-half as much chlorine as was added in the morning, which addition should again bring the color near that of the maximum tube. (0.5 p.p.m.).

SUMMARY

Maintenance of a minimum of 0.2 p.p.m. available chlorine in a swimming pool is sufficient to eliminate colon group organisms and ensure low agar counts.

Coöperation of pool managers in using the residual chlorine outfits provided by the Division of Health will result in safe swimming pools with the substitution of simple chemical control for more complicated bacteriological control.

ORTHO-TOLIDIN AND STARCH-IODIDE TESTS FOR FREE CHLORINE IN CHLORINATED SEWAGE TANK EFFLUENTS

Walter V. D. Tiedeman[1]

Buswell and Boruff have discussed the relative sensitivity of ortho-tolidin and starch-iodide tests for free chlorine in a recent article in This Journal.[2] We are led to comment on this subject in order to bring out certain points of general interest which have developed from attempts by the Division of Sanitation of the New York State Department of Health to make practical application of these two tests to chlorinated sewage tank effluents. We find a wide discrepancy between the results obtained by the ortho-tolidin, as compared with the starch-iodide, test when applied to relatively fresh domestic sewage.

Our interest in the application of a test for excess chlorine in chlorinated sewage effluents has been from the standpoint of practical plant operation in places where, due to nearby shellfish grounds, bathing beaches or water supplies, an effluent of low B. coli content is required. A general survey of sewage chlorination plants on Long Island, operating on a fixed chlorine dosage supposed to meet maximum requirements and treating effluents from either Imhoff or plain settling tanks handling only domestic sewage, revealed that the reduction in bacteria as a result of chlorination was slight under summer conditions in most cases. This was particularly true of the B. coli group. The fluctuation in the chemical demand for chlorine, probably due to differences in dissolved organic matter and gases such as hydrogen sulphide, was much greater than was commonly recognized. (1) Hence, in order to fix a rate of application for chlorine, to be used the year round, in parts per million, pounds per million gallons of sewage or pounds per day as most small plants operate, it is necessary to fix this on a basis of the maximum demand

[1] Division of Sanitation, New York State Department of Health, Albany, N. Y.

[2] November, 1925, page 384.

for chlorine under summer conditions and on a basis of maximum flow. Our experience indicates that to do this is increasing the operating cost for chlorine to the point where the question is raised as to whether more complete treatment would not be more economical. (2) It was also found that plant operators were inclined to look upon the proper chlorine dosage as a matter of the application of a fixed number of pounds per day and that in plants located in rapidly developing sections the rate of sewage flow might increase as much as 50 per cent over that on which the chlorine dosage was estimated, without any increase in the amount of chlorine used. There was also a tendency to base the rate of applying chlorine upon the average rather than the maximum daily flow. (3) In some sewage disposal plants, there were no means of measuring the sewage flows and the amounts of chlorine added daily were based on rough estimates which were generally low. (4) The control of sewage disposal plants by bacterial analyses was also found to be unsatisfactory. This was due principally to the fact that several days were required to secure presumptive results and, where work was done in city laboratories, additional time was consumed shipping samples and returning the report. Another unsatisfactory factor, where bacterial samples were shipped for examination, was that excess chlorine was not removed from the samples and where an excess was present, the reaction period for the chlorine included the time it took to ship samples to the laboratory.

All these conditions pointed to the advantages of securing some quick test that would indicate when satisfactory removal of bacteria was being obtained. Steps were taken to determine the possibilities of operation on an excess chlorine basis as indicated by either the ortho-tolidin or the starch-iodide tests as is done in water chlorinating plants.

Since the turbidity of sewage interferes with the reading of excess chlorine by the ortho-tolidin method in Nessler tubes, these tests were made in ordinary one ounce prescription bottles following a suggestion by L. H. Enslow. A bottle of the sewage or effluent being tested was placed in front of the standard to get the effect of the turbidity and a bottle of plain water was placed in front of the bottle of sewage or effluent to which the ortho-tolidin had been added, to equalize the depth of liquid and amount of glass looked through. The comparison was made by looking through the two bottles in each case.

At least 1 cc. of standard ortho-tolidin solution is necessary to

produce the reaction in the small bottles (about 4 cc. per 100 cc.). The length of time required to reach the maximum reading was from 5 to 15 minutes, depending particularly upon the temperature and strength of sewage. In some cases with cold sewage as much as 30 minutes was required for the color to reach a maximum. It was found that the addition of about 2 cc. of concentrated hydrochloric acid per 100 cc. of sample added after the ortho-tolidin or immediately before would speed up the reaction, but if two or three minutes' time were allowed for the acid to react before the ortho-tolidin was added, the latter would develop no color at all. At 5.5°C. an excess of 2.9 p.p.m. in sewage by the ortho-tolidin standard was developed in twenty-five minutes whereas in a sample of the same chlorinated sewage warmed to 21.5°C. the same maximum reading was obtained in 5 minutes. It was also noted that reactions with ortho-tolidin are much slower with strong sewages than with weak sewages and that the color fades rather rapidly in a strong sewage.

As a check on the ortho-tolidin test the excess chlorine was determined by titration with N/100 sodium thiosulphate using c.p. potassium iodide crystals and acidifying with about 3 cc. per 100 of glacial acetic acid and using starch solution as an indicator. It developed that the excess chlorine indicated by this titration with relatively fresh chlorinated tank effluents was always much higher than the excess indicated by the ortho-tolidin test. The difference was neither fixed nor directly proportional, but varied with the strength of the sewage and the amount of the excess. Some of these comparative results are listed in table 1.

It is difficult to explain definitely the difference in results obtained by the two tests. Chlorine very likely enters into some combination which does not react with ortho-tolidin, but which is released by acidification and reacts as free chlorine in the starch-iodide titration.

In order to check the solutions and computations a few excess chlorine determinations were made on tap water treated with chlorine, bleach and zonite, respectively. With these substances the results checked more closely, although there was a tendency for the ortho-tolidin test to give higher rather than lower results. Some of the results obtained are shown in table 2.

The higher values for excess chlorine by the ortho-tolidin test may be partially explained by the fact that the standards used in the small bottles were prepared for use in 100 cc. Nessler tubes. A reading of

the excess chlorine in a zonite solution by the ortho-tolidin test in the small bottle as compared with the Nessler tube was 2.5 against 2.0. Further work is contemplated in determining this factor.

TABLE 1

Comparison of results of determination of excess chlorine by ortho-tolidin and by starch-iodide titration†*

EXCESS (O-T‡)	CHLORINE (S-I§)	EXCESS (O-T‡)	CHLORINE (S-I§)	EXCESS (O-T‡)	CHLORINE (S-I§)	EXCESS (O-T‡)	CHLORINE (S-I§)
0	0.4	0.4	4.8	1.4	3.1	2.5	7.9
0	0.9	0.5	3.5	1.5	7.0	2.7	4.5
0	1.3	0.5	8.0	1.6	4.0	2.9	4.0
0	1.8	0.7	1.4	1.8	8.6	3.0	4.4
0	2.2	0.7	3.3	2.0	4.9	3.0	5.1
0	2.6	0.7	3.8	2.0	5.3	3.0	5.8
0	3.1	1.0	4.2	2.2	4.0	3.0	8.8
0	3.5	1.0	5.3	2.2	6.6	3.0	15.0
0.1	5.3	1.2	3.8	2.3	4.2	3.2	4.5
0.2	2.8	1.3	3.2	2.3	6.1	3.2	7.7
0.3	2.6	1.3	3.3	2.5	5.8		

* Results are for various samples of chlorinated sewage tank effluent at various times.

† Acidified with acetic acid.

‡ O-T. Ortho-tolidin test.

§ S-I. Starch-iodide titration using acetic acid.

TABLE 2

Excess chlorine in tap water

TREATMENT	BY ORTHO-TOLIDIN	BY STARCH-IODIDE (USING ACETIC ACID)
Treated with chlorine	2.8 1.5 3.5	2.0 0.7 2.8
Treated with bleach	3.4	2.4
Treated with zonite	2.5†	2.1

* Readings made in 1-ounce bottles as for sewage tests, using 1 cc. of ortho-tolidin solution.

† A reading of 2.0 was obtained on the same solution in a 100 cc. Nessler tube using 1 cc. of ortho-tolidin solution.

As a further check on the work, The Division of Laboratories and Research sent out a man from the Albany laboratory who substan-

tially duplicated the results. He also pointed out that the starch-iodide test omitting the acetic acid gave results which checked approximately the readings obtained by the ortho-tolidin test. Comparative readings on the same sample of chlorinated sewage by various methods gave the results in table 3.

The determination by unacidified starch iodide titration approximately checks the result by the ortho-tolidin test and the result of the determination by the starch-iodide method using hydrochloric acid is slightly higher than that obtained by using acetic acid. Other results have borne this out.

To determine the bacterial removal obtained with various excesses of chlorine by the ortho-tolidin test, as compared with starch-iodide titration using acetic acid, a series of bacterial samples were taken and sent by special messenger to the New York City branch laboratory of the Department for analysis. In order to terminate the

TABLE 3

Comparative tests for excess chlorine by ortho-tolidin and by starch-iodide titration with and without acid

1. By ortho-tolidin test*	3.0
2. By starch-iodide titration *without acid*	2.8
3. By starch-iodide using 0.3 cc. glacial acetic acid per 100 cc.	5.1
4. By starch-iodide using 4 cc. of 10 per cent HCl† per 100 cc.	5.8

* In 1-ounce bottles using 1 cc. of ortho-tolidin solution.

† Equivalent to the amount of HCl used in the ortho-tolidin test.

period of contact of the excess chlorine at a definite time, sufficient sodium thiosulphate to neutralize the excess chlorine was used. It was determined that the sodium thiosulphate solution did not inhibit bacterial growth, but, notwithstanding this fact, only a slight excess over the amount indicated as necessary by starch-iodide titration using acetic acid was added. Some of the results are given in table 4. The tests for the B. coli group are the completed tests of "Standard Methods." These tests were made during October and November and the total demand of the sewage for chlorine is much lower than under summer conditions.

The first series was made with fixed chlorine dosage sufficient to give a decided excess by the ortho-tolidin test. The detention period was varied for the purpose of determining whether removal of B. coli could be obtained with short detention periods under these conditions. The shortest period (8 minutes) shows a removal of bacteria on agar

TABLE 4

Summary of results of bacterial analyses of sewage tank effluent at Huntington, Long Island, New York

New York State Department of Health

	DATE	SOURCE OF SAMPLE	CHLORINE DOSAGE (CALCULATED)	EXCESS CHLORINE				REACTION PERIOD	BACTERIAL COUNT		COMPLETED TEST FOR B. COLI					
				Initial*		Final†										
				Orthotolidin	Acetic starch iodide	Orthotolidin	Acetic starch iodide		At 20°C. on gelatin	At 37°C. on agar	10 cc.	1 cc.	1/10 cc.	1/100 cc.	1/1000 cc.	1/10000 cc.
	1925		*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*min-utes*								
		Raw sewage							2, 200, 000	2, 500, 000	2+0–	2+0–	2+0–	2+0–	2+0–	2+0–
		Untreated tank effluent							1, 900, 000	2, 300, 000	2+0–	2+0–	2+0–	2+0–	2+0–	0+2–
Series I	10/22	Treated tank effluent	13	0.5	8.0		7.0	8‡	1, 000	1, 800	2+0–	2+0–	2+0–	2+0–	0+2–	0+2–
		Treated tank effluent	13	0.5	8.0		7.0	15	800	600	2+0–	2+0–	2+0–	1+1–	0+2–	0+2–
		Treated tank effluent	13	0.5	8.0		6.6	30	900	7, 300	2+0–	2+0–	2+0–	2+0–	0+2–	0+2–
		Untreated tank effluent							1, 200, 000	1, 400, 000	3+0–	3+0–	3+0–	3+0–	3+0–	0+3–
		Treated tank effluent	2.7	0	1.3	0	0.9	10§	150, 000	140, 000	3+0–	3+0–	3+0–	3+0–	3+0–	0+3–
Series II	10/28	Treated tank effluent	2.7	0	1.3	0	0.9	20	140, 000	65, 000	3+0–	3+0–	3+0–	3+0–	3+0–	0+3–
		Treated tank effluent	2.7	0	1.3	0	0.4	30	74, 000	5, 500	3+0–	3+0–	3+0–	3+0–	3+0–	0+3–
		Treated tank effluent	2.7	0	1.3	0	Trace	60	29, 400	2, 100	3+0–	3+0–	3+0–	3+0–	2+1–	0+3–
		Untreated tank effluent							15, 700, 000	1, 200, 000	3+0–	3+0–	3+0–	3+0–	3+0–	1+2–
		Treated tank effluent	7.4			0	3.1	15	400	300	3+0–	3+0–	0+3–	0+3–	0+3–	0+3–
		Treated tank effluent	9.5			0	3.5	15	3, 400	100	3+0–	3+0–	3+0–	0+3–	0+3–	0+3–
Series III	11/5	Treated tank effluent	11.2			0.4	4.8	15	300	0	3+0–	3+0–	0+3–	0+3–	0+3–	0+3–
		Treated tank effluent	12.8			2.2	6.6	15	300	100	3+0–	3+0–	0+3–	0+3–	0+3–	0+3–
		Treated tank effluent	14.3			2.5	7.9	15	800	0	3+0–	3+0–	0+3–	0+3–	0+3–	0+3–
		Treated tank effluent	15.3			3.0	8.8	15	0	200	3+0–	0+3–	0+3–	0+3–	0+3–	0+3–

Series IV	11/17	Untreated tank effluent							7,600,000	1,600,000	3+0−	3+0−	3+0−		3+0−	0+3−
		Treated tank effluent		0.8		0.6	2.7‖‖	15	0	40	0+3−	0+3−	0+3−	0+3−	0+3−	0+3−
		Treated tank effluent		0.8		0.6	2.7††	15	40	70	1+2−	0+3−	0+3−	0+3−	0+3−	0+3−
		Treated tank effluent		0.8		0.6	2.7‡‡	15	1,400	3,000	0+3−	1+2−	0+3−	0+3−	0+3−	0+3−
		Treated tank effluent				2.9	6.0‖‖	15	10	90	0+3−	0+3−	0+3−	0+3−	0+3−	0+3−
		Treated tank effluent				2.9	6.0††	15	30	90	0+3−	0+3−	0+3−	0+3−	0+3−	0+3−
		Treated tank effluent				2.9	6.0‡‡	15	3,700	27,000	3+0−	3+0−	3+0−	2+1−	0+3−	0+3−

* Determined immediately after the addition of the chlorine.

† Determined at the end of the reaction period after which the excess chlorine was neutralized by adding a slight excess of sodium thiosulphate above amount indicated as necessary by the starch iodide titration using acetic acid except as noted in footnotes **, †† and ‡‡.

‡ Estimated period of detention in chamber. Longer periods in this series represent detention in a pail out of doors.

§ All detention periods represent detention in a pail out of doors.

‖‖ Excess removed by adding an amount of sodium thiosulphate indicated by the unacidified starch iodide titration.

†† Excess removed by adding an amount of sodium thiosulphate indicated by the starch iodide titration using acetic acid.

‡‡ Excess removed by adding an amount of sodium thiosulphate equal to 10 times that indicated by unacidified starch iodide titration.

at 37° of 99.29 per cent and the absence of B. coli in $\frac{1}{10,000}$ cc. with the presence of B. coli in $\frac{1}{100}$ cc., which may be considered very satisfactory for average conditions. The second series was run with fixed chlorine dosage low enough to give no reaction for excess chlorine by the ortho-tolidin test but a slight excess by starch-iodide titration using acetic acid. The detention period was varied with a view to determining whether such an excsss would give satisfactory bacterial results with short detention periods. The results indicate a removal of bacteria according to the 37° count of from 90 per cent for ten minutes detention to 98.5 per cent for one hour detention, but practically no reduction in B. coli with less than one hour's detention and even then 2 out of 3 of the $\frac{1}{10,000}$ cc. portions were positive. These results would indicate that the bacterial effect of the chlorine combinations reacting as free chlorine by acidified starch-iodide titration, but giving no reaction by ortho-tolidin, cannot be depended upon for a material reduction of colon bacilli where the detention period is one hour or less. The third series was run with a fixed detention period but variable chlorine dosage. Unfortunately the range of chlorine dosage was not started low enough to bring out the point where good bactericidal action began. It is of interest to note that good results were obtained with the first two samples in this series in which samples no excess of free chlorine was indicated by the ortho-tolidin test. It may be noted, however, that in these instances the excess by starch-iodide (acidified) titration was more than 3 p.p.m. The fourth series of samples was collected for the purpose of determining the effect upon the bacterial results of the addition of sodium thiosulphate solution for the removal of the excess chlorine. This series consists of two sets each comprised of 3 identical samples of chlorinated tank effluent which have been treated after 15 minutes reaction with varying amounts of sodium thiosulphate tending to neutralize the excess chlorine. The results of this series show: (1) That sodium thiosulphate solution in decided excess over that necessary to neutralize the free chlorine apparently has no inhibitory effect upon the growth of bacteria of the B. coli group and (2) that a slight excess of sodium thiosulphate is necessary and a decided excess preferable to make sure that no chlorine combination remains which might react in the sample on the way to the laboratory.

In conclusion it may be said that:

1. The variations during the course of the year in the chemical demand for chlorine in the effluents of tanks treating ordinary domestic sewage are greater than are commonly recognized.

2. Many sewage chlorination plants treating Imhoff or plain settling tank effluent on a fixed chlorine dosage of 15 p.p.m. were turning out unsatisfactory effluents from the standpoint of B. coli removal and in a few instances showed only slight bacterial removal under summer conditions.

3. In operating sewage chlorinating plants on the basis of a definite number of parts per million of chlorine to be applied the year round, we must fix this figure high enough to produce good results under summer conditions,[3] i.e., under conditions requiring a maximum amount of chlorine. This raises operating costs materially indicating the advantages of varying the dosage as in operating on an excess chlorine basis.

4. The ortho-tolidin test for excess chlorine is applicable to sewage tank effluents by substituting 1 ounce prescription bottles for Nessler tubes, increasing the amount of ortho-tolidin and allowing for the turbidity as described, although results are at variance with those obtained on fresh sewages by starch-iodide titration using acetic acid. In other words, the ortho-tolidin test is a valuable index regardless of whether or not it is a true measure of excess chlorine.

5. Tests indicate that good bacterial removal and reduction in B. coli can be obtained in chlorinated effluents of tanks treating domestic sewage when a slight excess of chlorine is indicated by the ortho-tolidin test.

The practical operation of the sewage treatment plant at Huntington, Long Island, New York, has been started on an excess chlorine basis and monthly chemical and bacterial samples to be collected throughout this year should add interesting data. The bacterial work on these samples includes the examination of the suspended solids for B. coli.

[3] At the Port Washington plant about 26 p.p.m., i.e., 215 pounds per million gallons were necessary to secure good results late in August.

THE NEED FOR DATA RELATING TO WATER[1]

By N. C. Grover[2]

Water is the most valuable of minerals. Man can do without iron, copper, silver, or gold, but he cannot get along without water, which is essential to all life whether plant or animal. It must be available for domestic and municipal supplies in such quantities and of such quality as to maintain comfort and health, and to supply the ordinary household needs; for all growing crops—in humid regions by the natural processes of nature in the form of rain and snow and in arid regions by means of artificial systems of irrigation; for process uses in industry, many of which need water of clarity and purity; and for water-power and steam-power plants to supply the electric energy which lights our homes and streets, drives our railway cars, and operates our factories. Whether energy is obtained from falling water or burning fuels, water is essential and limits the capacity of the steam plant just as surely as it does the hydraulic plant. In addition, water plays an important part in all recreation and is essential to bathing, boating, canoeing and fishing.

Air is also necessary to life, but except under unusual conditions of congestion or stagnation it is available at all times and places in any quantity and of good quality at no cost. But water is not always available; it is definitely limited in quantity and is often of poor quality. It must be diverted from streams by means of expensive dams and canals or pipe lines, or it must be pumped from the ground, stored in reservoirs, softened, filtered, clarified, purified, sterilized, decolorized, deodorized and what not, in order to meet the requirements of modern man. As water lacks in quality, its utilization becomes more expensive and less satisfactory. Moreover, it must be available at the instant on the turning of the faucet in the home of our present civilization. Under these conditions water is not and cannot be free. The user must pay the cost either in the form of a water bill or in his general taxes, or in the cost of a private supply obtained from well or stream by means of pump or gravity aqueduct.

[1] Presented before the Iowa Section meeting, December 3, 1925.

[2] Chief Hydraulic Engineer, U. S. Geological Survey, Washington, D. C.

Water forms the foundation of value in many modern developments and activities which are limited by the quantity of water available. The great marvel of the times is the continued enormous growth in the use of electrical power. The statistics collected by the United States Geological Survey show that during the last five years this use has increased at the rate of more than 10 per cent a year, with no present sign of abatement. The great use of this force, which is at the foundation of our present prosperity, has relieved labor of much of its drudgery, has given each laborer, on the average, several horsepower of cheap assistance, enabling him to double and triple his earning capacity, has changed the whole scale of living, and has made the ordinary home of today more livable and healthful than a king's palace of a century ago. This situation has been set forth in Secretary Hoover's report for the Department of Commerce for the year ending June 30, 1925.[3]

As water is expensive when made available for use, mistakes should be avoided in the planning of water supply systems that may fail in whole or in part to serve the uses for which they are designed. The quantity and quality of water must be carefully studied at its source, and full and reliable data must be available as a basis for all plans for using it.

The supply of water is strictly limited and the total quantity in any region cannot be changed. It may be stored from periods of floods to periods of drought or it may be supplemented in one river basin by diversion from another, but except by these obvious and simple, though sometimes expensive, expedients the available supply cannot be increased. The limit of the supply that may be obtained from the ground, though not as obvious, and generally not as surely measurable in advance of use, is just as definite. No more water can be pumped from the ground in a given region than flows into it at such places and times as to reach the pumps.

The water in surface streams which form our principal source of supply, varies widely in quantity from season to season and at low stages is not generally sufficient for the uses that are made of it. It varies also in quality with variations in stage, and at times, even after expensive chemical treatment, serves very unsatisfactorily and inefficiently the needs of man for domestic or industrial use.

A knowledge of either or both the stage and discharge of rivers is needed in connection with the design and construction of flood protec-

[3] Reviewed in The Literary Digest, December 12, 1925, p. 12.

tion works, the determination of the necessary capacities of culverts and bridge openings, the elevations of grades of railroads and highways, and the elevations of buildings situated on the banks of rivers or on their flood plains. For these uses there is involved a necessity for topographic maps in connection with the determination of capacities of possible storage reservoirs, and with planning the routes for canals and other diversion conduits, also for information on the geologic structure of beds and banks with respect to their strength for supporting dams and other structures, and to their water tightness when subjected to considerable hydrostatic pressures.

With the development of the country and its growth in population, industry, and commerce, there has been a steady increase in the need for water. As towns and cities have continued to grow, new and increased supplies of soft, unpolluted water must be sought or the supplies now used that are not safe for drinking or satisfactory for household use must be so treated as to make them safe and satisfactory.

There is constant searching for more and better water for industrial processes, and both the quantity and quality of the available supplies of water now determine the locations chosen for many industries. In order that reliable information as to water supplies shall be available when use for it arises the needs of the future must be anticipated, because time is required for getting the records. If action is delayed, the records will not be available when needed and there will be many failures of hydraulic projects because developments will necessarily have been made without sufficient information to show the limits and qualities of the supplies of water upon which reliance is to be placed.

As would be expected, the increased use of water has been reflected in a growing demand for fundamental data as to the quantity and quality of the water flowing in all of our rivers and to be obtained from the ground, and in an appreciation of the value of water and of the importance of knowledge of its quantity, quality, and availability. The United States Geological Survey is the authorized Federal agency for collecting and publishing data pertaining to water and is the recognized source of reliable information on all questions relating to water supply.

The demand for information as to water has led many States to coöperate with the United States Geological Survey and to appropriate large amounts of money for use in such coöperation, which

has grown in recent years until the Survey does little more than furnish the equivalent of salaries of the supervising officials; other expenses being paid by the coöperating parties. During 1925, the total Federal appropriation was $165,000, and during the same year more than $400,000 was furnished by states, counties, and municipalities, and by corporations operating under the Federal Water Power Act. The continued demand for extension of the resources of the Geological Survey to be used in this coöperation has recently culminated in the effort of the American Engineering Council to provide for an inventory[4] of the country's water resources and to establish an adequate program for collecting and publishing the basic facts.

In a statement concerning the needs for this inventory, American Engineering Council has summarized the reasons why the work should be centralized and systematized under the United States Geological Survey as follows:

1. The Geological Survey is primarily a bureau of research and investigation that collects systematically and publishes for general information and use data in regard to the natural resources of the country and it is recognized as an authorized Federal agency for collecting and publishing information in regard to all questions relating to water resources of the country.

2. The Geological Survey has an established personnel and facilities for carrying on the investigations. The methods used in conducting the work have been developed as a result of years of experience and have been accepted as standard throughout the United States, and foreign countries. This insures coördination and standardization of all investigations conducted by the Geological Survey or under its supervision.

3. The work of the Geological Survey is on a continuing basis and is reasonably free from danger of interruptions with changes in administration.

4. The Geological Survey is in position to make data readily available to the public by means of its publications and of other facilities.

5. It is highly important that base data in regard to water and other natural resources be collected by an unbiased agency not directly interested in construction or administration of specific projects or of specific types of projects in order that the public may have absolute confidence in the results. Moreover, agencies responsible for construction or administration are most soundly fortified if their actions are based on information collected by an accredited federal investigational bureau whose primary responsibility is that of making available unbiased facts.

---

[4] H. R. 6358, 69th Congress, 1st Session.

SEISMIC ACTIVITY IN SANTA BARBARA[1]

By V. E. Trace[2]

On the previous day of the disaster, June 28, at 8:15 p.m., 1925, the recording pressure gauge registered a slight disturbance and was so recorded on the seismograph in the City of Pasadena.

June 29, 1925 at 6:42 a.m. the heavy shock occurred lasting about nineteen seconds. The pen point on the pressure gauge was thrown from 140 to 175 pounds. The destruction of two of the main trunk lines drained the system and within ten minutes the water pressure registered 5 pounds, and within less than thirty minutes thereafter, through the quick action of the Water Department employees in closing the damaged sections of the system, the pressure in the system was restored and it is with gratitude I wish to state that the employees responded without call and were ready to render their assistance immediately following the disaster. At 10:45 a.m. the pressure was 75 pounds and at 12:00 noon was normal.

Through the destruction of the dam at Sheffield Reservoir, two sections of the East Transmission Main to the lower distributing reservoir no. 1, the 16-inch distributing main from reservoir no. 1 and a 6-inch main crossing Sycamore Canyon Creek were washed out.

Carl Wyant, Engineer and Superintendent of the Montecito County Water District, with his employees were on hand to render assistance and were certainly appreciated. The two sections of the East Transmission Main were replaced by them and the service of reservoir no. 1 was resumed within forty-eight hours.

The first break in the system noticed was the 12-inch Class B Cast Iron Main on State Street, and was caused by the falling of a top wall from a three story building landing directly over, and driving the pavement 3½ feet into the ground. Two blocks of this main were closed off leaving one fire hydrant at each street intersection available for fire service.

The 16-inch main crossing Sycamore Canyon Creek was closed

[1] Presented before the California Section meeting, October 15, 1925

[2] Superintendent, Water Works Department, Santa Barbara, Calif.

off by gates being located on each side of the stream, leaving an 8-inch main still intact from reservoir 1 that passed over a concrete arch bridge which was not damaged.

Two blocks of the 6-inch main crossing this stream were closed and later plugged at the embankment and service resumed to the consumers.

During this operation the writer with other employees proceeded to the Sheffield Reservoir for investigation and found it was destroyed, but the supply main was still in operation. Gates were operated and the water by-passed into the transmission mains from Sheffield Reservoir, supplying reservoirs 2 and 3 located near the old Mission, and also reservoir 1. We then proceeded to the South Portal of the Mission Tunnel and got in communication by phone with the caretaker at Gibraltar Dam. He reported no damage.

Observations of the ventilation and weir measurements of the flow of water through the tunnel were taken every half hour by the caretaker to ascertain if any obstruction had taken place in the tunnel.

No decrease in the flow was observed at any time, but there was an increase which was due to the opening up of additional springs in the tunnel, which increase was about 75 per cent or 1,000,000 gallons per day.

After reporting to Herbert Nunn, our City Manager, that the water supply was in operation, I proceeded to investigate the additional damage to the distributing system.

The 8-inch cast iron main that crosses the bridge on Haley Street broke within 6 inches of the concrete wall, a section was removed and replaced by the use of two sleeves, all joints calked with lead, without removing a section of the wall.

The 8-inch cast iron main on Mason Street, between State and Bath Streets was severely shaken, causing several leaks in lead joints, also fracturing two cement joints and shearing off several services at the corporation cock.

On Chapala Street, between Mason and the West Boulevard, one cement joint was fractured and one service sheared off. The most severe movement occurred in this section of the City since it is in or near the fault line and on filled ground.

The south rail on the Santa Barbara Suburban Railroad on the West Boulevard was bucked and twisted. The pavement on Mason Street was raised and overlapped and several sections of curbing broken.

A section of the 8-inch de Lavaud cast iron pipe in Cliff Drive near the Arroyo Burro Creek moved ahead $2\frac{1}{2}$ inches and was replaced with a longer section. At the end of this line an 8-inch gate valve was broken without fracturing the de Lavaud cast iron pipe.

In various sections of the City where 2-inch standard pipe was installed the joints were buckled.

At the pumping station, the 10-inch standard screwed discharge main from the pumps connecting with the distributing system, separated at the joints. The caisson, 30 feet deep and 25 feet in diameter,

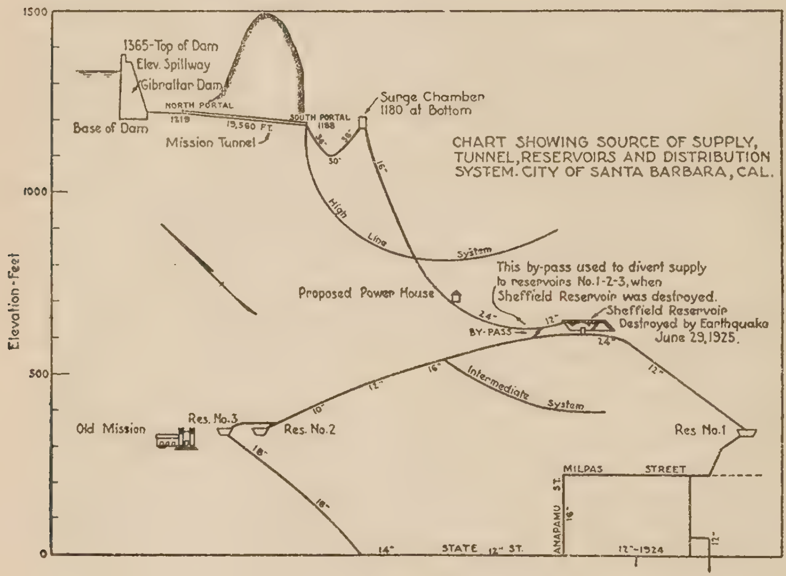


FIG. 1

was fractured and flooded the pumping pit with water. The brick walls housing the boiler room were demolished.

In Montecito Street, between Bath and Castillo Streets, a lead joint was leaking and the expansion joint in the pavement raised. In Bath Street, between Haley and Cota Streets, one lead joint was leaking and the pavement was shattered. At the intersection of San Pasqual and Ortega Streets a gate box cap was sheared off from the socket.

The supply main between the South Portal of the Mission Tunnel and the concrete surge chamber, consists of 30 and 36-inch continuous redwood stave pipe and 36-inch reinforced concrete pipe. The

concrete pipe being a short section of about 50 feet, connecting with the surge chamber and the redwood pipe, was cracked in three places; two were vertical and one horizontal in the elbow underneath the surge chamber. One vertical crack was repaired by the construction of a concrete sleeve, a space was left over the crack and filled with black adobe and thoroughly tamped. The other vertical crack was repaired by the use of a steel sleeve placed on the inside. The joint was packed with oakum, black adobe and the face calked with lead wool. The horizontal crack was chipped out and calked with lead wool and a plastic of duck mastic was placed over the lead wool, covering the crack.

The dam forming the Sheffield reservoir was a puddled earth-fill, maximum height 25 feet and 800 feet long, without a drainage system. The face of the fill was puddled with black adobe, 4 feet at the bottom and 2 feet at the top and 9 feet in depth below the bottom of the reservoir, a concrete cut-off wall 1 foot thick and 5 feet in depth, placed in front of the adobe, the concrete lining extended therefrom covering the face of the dam.

Upon examination of the old structure that was left after the major portion went out, we found that the adobe facing and cut-off wall was perfect, no water having percolated through the adobe, but the hydrostatic pressure in the reservoir caused the water to percolate underneath the cut-off wall and adobe fill and saturate the bottom of the main structure.

When the heavy shock took place, the dam opened near the south end and about 500 feet in the center slid out on a hinged form.

The destruction of the dam at Sheffield Reservoir reduced the storage of water supply, near the City, from 43 to 4 million gallons. The water supply being diverted from the Gibraltar Reservoir required an excess of water to supply the system, therefore, causing more or less waste of water. Immediately steps were taken to reconstruct the dam on the old site for temporary storage of 8 to 10 million gallons, but the construction was of permanent nature until such time that finances could be raised to restore the original capacity.

After completing the temporary storage of the Sheffield Reservoir, inspection was made of the Mission Tunnel, 19,560 feet in length, through which the water supply from Gibraltar Dam is diverted. No disturbance was observed.

Immediately following the disaster, June 29, it was reported that

the water supply of the City of Santa Barbara was contaminated. This statement was uncalled for. The water diverted from the Gibraltar Reservoir through the tunnel is chlorinated at the South Portal, making the water safe at all times for domestic purpose supplying high service and before entering Sheffield Reservoir. Another plant was at Sheffield Reservoir and chlorinated the water passing through the transmission mains to the lower reservoir.

Considering the intensity of the seismic activities in our City, the result of the damage to the distributing system was negligible compared with the damage to buildings and other structures. There was only one cast iron pipe on this system that actually broke from the movements of the earth.

The greatest menace to be considered is the falling of walls from high buildings into the streets, causing the destruction of water mains and appurtenances.

ENGLISH COMMENTS ON ADDITION OF IODINE TO DRINKING WATER TO PREVENT THYROIDISM[1]

One of the most remarkable prophylactic experiments of recent times is being carried out at Rochester (U. S. A.) by which iodine in the form of sodium iodide is being added artificially to the water supply twice a year for a period of some two or three weeks with the idea of preventing the occurrence of thyroidism.

In this connection it would appear an amazing proposition that the great majority of water consumers who are doubtless free from goitrous affections should have to drink an iodised water in order to benefit the few who are not so happily placed. The obvious conclusions being that the iodine treatment should be limited to the actual sufferers, but this feeling of hostility is hardly justifiable.

In the first place, it must be noted that it is not the actual cases that it is sought to cure, but the possible sufferers, in other words it is an attempt to prevent the development of the affection in those who otherwise would not escape, and as it is impossible to diagnose in the case of children and young adults which are and which are not destined to be affected, the experiment aims at safeguarding the interests of the few by treating the whole water supply with iodine.

Secondly, the dose is very minute, viz.: 16.6 pounds to 25,000,000 (U. S.) gallons or 0.008 pound per 100,000 pounds (= 10,000 imperial gallons) and with this dosage no danger to health would seem to be possible either to the potential sufferers or to those who have no need of the treatment.

Thirdly, it has been known for years that a deficiency of iodine is the best, if not the only satisfactory explanation of the cause of ordinary goiter.

Water has been blamed at one time or another for most of the ills of suffering humanity including thyroidism. Pure and impure, hard and soft, and generally waters of quite dissimilar qualities have been thought to be a contributory cause. There is not appar-

[1] From the Chemical Laboratories of the Royal Institute of Public Health. The Journal of State Medicine, vol. 34, No. 1, January, 1926, page 59.

ently any combination of water supplies peculiar to goitrous districts throughout the world which throws any definite light on this obscure problem. The consensus of opinion, however, is in favour of iodine as a prophylactic, although, the manner of introduction of the drug is a matter for serious concern. Much depends on the incidence of the disease, and what may be permissible or desirable at one place may be unjustifiable at others. It is now no longer held that the hardness of water is connected with goiter.

Several difficulties may present themselves in the wholesale application of iodine to water supplies.

People drink very variable amounts of water and so would ingest very varying amounts of iodine. If the proportion of iodine in the water is kept too low the dose may be insufficient to produce the desired effect, unless an undesirable or impossible volume of water is consumed. There are also conditions of thyroid disease associated with enlargements of the gland in which such treatment with iodine is directly contra-indicated.

While the amount of iodine suggested to be added is extremely small it may however be questioned, if the ingestion of minute quantities of iodine compounds has so powerful an action that it will prevent the development of the disease in those prone to it, whether in the healthy body, which does not need such an addition, the possibility of a disease of a contrary nature might not be set up.

Even in districts where thyroid enlargements are particularly common the number of sufferers would only be a minority of the population, and it may be questioned whether it is right to submit the whole population to a regime serviceable to this minority only.

Consequently any form of medicinal treatment applied promiscuously must be carefully watched less there be a danger to the community at large.

Before sanctioning the addition of iodised water on a large scale irrefutable proof must be produced that it is harmless to the healthy.

While it is true that an intake of iodine compound is essential for life, it is also true that the iodine ingested normally is not in the form of a simple chemical compound (such as sodium iodide), but composed of highly complex organic substances, and it is probable that the body may be capable of regulating the intake of these substances in the form with which it has learnt to deal with them, and yet not be capable of regulating its supply from chemical compounds unfamiliar to it.

The use of iodine containing substances for goitrous affections dates back hundreds of years. Some thirty years ago iodine was shown to be normally a constituent of the thyroid gland, and it is now fairly generally agreed that if the store of iodine falls below 0.1 per cent of the total amount of dried gland tissue, hypertrophic and other changes are liable to occur.

Although it seems likely, if not certain, that the wastage is due primarily to a deficiency of iodine in liquid or solid foodstuffs or accessories it may be true that the gland in some way conserves its store, provided no toxic factor is introduced to upset the equilibrium of its normal working.

Although the artificial exhibition of iodine has been shown to be a prophylactic measure of some value, this does not necessarily prove that the essential cause of thyroidism is solely due to a deficiency or absence of iodine in the diet. It may only mean that when certain mysterious states of toxicity exist, the only way to prevent the sustained loss of iodine is to counteract the loss by sustained ingestion.

As regards methods of iodine administration, inhalation and external application are unsatisfactory as compared with internal administration. In the Akron (Ohio) schools, 3 grain doses of sodium iodide were given in the drinking water once a day for two weeks in the spring and again in the autumn. The Swiss authorities favor the use of iodine and chocolate tablets, throughout the entire country, the Austrian authorities advocate the use of iodised salt.

At Rochester, as indicated previously, water is iodised, and as people drink very variable amounts of water, so in practice differing amounts of iodine would be ingested. The dose of sodium iodide given in the British Pharmacopoeia is 5 to 20 grains, but very much smaller doses suffice apparently for thyroid prophylactic treatment. The Rochester dose amounts to 0.056 grains of sodium iodide per gallon of water. If the dose be materially increased there is possibly some danger of heavy water drinkers receiving too much iodine, and it cannot be denied that in certain hypersusceptible persons, iodine would seem to be actually contra-indicated.

The Rochester experiments cannot be ignored, and if any risks exist they can easily be greatly exaggerated, and if there are no tangible risks it would seem the exhibition of iodine by the water supply is the only practical way potential sufferers from thyroidism can be required to undergo treatment with a drug which the consensus of opinion agrees is of definite prophylactic importance.

DISCUSSION

STANDARDIZATION OF CAST IRON PIPE

A standardization project of far-reaching importance is about to be inaugurated through the formation of a representative Committee on Cast Iron Pipe which will undertake a general program of unifying existing specifications for cast iron pipe into a consistent set of nationally recognized specifications. This committee, which will be officially known as the Sectional Committee on Standard Specifications for Cast Iron Pipe, is being sponsored by the American Gas Association, American Society for Testing Materials, American Water Works Association and New England Water Works Association and will function under the procedure of the American Engineering Standards Committee.

This development is the outcome of the submission two years ago by the American Gas Association of its Standard Specifications for Cast Iron Pipe and Special Castings to the American Engineering Standards Committee for their approval as American Standard Specifications. It became evident that consideration of these specifications for such approval would involve the standardization of cast iron pipe in general, and at a conference held under the auspices of the American Engineering Standards Committee, which was very widely representative of industries that produce and use this product, it became clear that whereas dimensional standardization was principally involved in the specifications for gas pipe, a broader treatment of the whole problem was essential if results of the greatest benefit were to be obtained. Thus at this conference the need of a study of the quality of metal in cast iron pipe and the problem of suitable coatings were emphasized as ones of primary importance to water works engineers. Recently developed methods of producing cast iron pipe must be taken into consideration. The American Gas Association was entirely willing to have the project broadened, and upon the recommendation of the conference the American Engineering Standards Committee agreed to set up a broad program of standardization of cast iron pipe under its auspices and invited the American Gas Association, American Society for Testing Materials, American

Water Works Association and New England Water Works Association to sponsor the organization of a representative "sectional committee" to carry on the actual work of investigation and standardization.

The scope of the work has been defined as follows:

Unification of specifications for cast iron pipe, including materials; dimensions; pressure ratings; methods of manufacture (including such new developments as centrifugal casting), in so far as they may be necessary to secure satisfactory specifications; elimination of unnecessary sizes and varieties; consideration of the possibility of developing a coördinated scheme of metallic pipe and fittings applicable to all common mediums; and methods of making up joints in so far as they are determining as to the dimensional design of cast iron pipe.

The types of cast iron pipe to include: bell and spigot pipe; flanged pipe; flanged and bell mouth fittings and wall castings; pipe elbows, tees, Y's, return bends, and other fittings not now included in standard lists; cast iron pipe threaded for flanges or couplings; soil pipe and other light types of cast iron pipe and fittings. The standardization is not to include methods of installing pipe and similar matters, except as to the making up of joints in its relationship to the dimensional standardization of pipe and fittings, as noted above.

The sponsors have been engaged in the details of organizing the sectional committee, which will comprise representative producers and users of cast iron pipe, and independent technical experts. Eleven technical societies and associations are represented in the work of the committee. This stage of the work is practically completed and the sponsors announce below the personnel of the committee.

The formation of this committee brings together for the first time the major technical societies interested in the various phases of the cast iron pipe problem and it is confidently anticipated that the coöperation of the producers and consumers upon the broad basis thus made possible will result in the development of national standards of quality and dimensions acceptable to all.

Plans for the formal organization of the committee in the near future are being made and will shortly be announced.

Submitted by AMERICAN SOCIETY FOR TESTING MATERIALS,
C. L. WARWICK, *Secretary-Treasurer.*

Personnel of Sectional Committee on Specifications for Cast Iron Pipe

American Gas Association

Walton Forstall, Engr. of Distribution, United Gas Improvement Co., Philadelphia, Pa.

H. E. Bates, Asst. Ch. Engr., Peoples Gas, Light and Coke Co., Chicago, Ill.

C. C. Simpson, Jr., Gen. Supt., Dept. Mains and Services, Consolidated Gas Co., N. Y. C.

American Railway Engineering Association

C. R. Knowles, Supt., Water Service, Illinois Central Railroad, Chicago, Ill.

Alternate:

C. P. Van Gundy, Water Engineer, Baltimore and Ohio Railroad, Baltimore, Md.

American Society of Civil Engineers

F. H. Stephenson, Asst. Supt., Detroit Dept. of Water Supplies, Detroit, Mich.

American Society of Mechanical Engineers

J. E. Gibson, Mgr. and Engr., Commissioners of Public Works, Charleston, S. C.

American Water Works Association

Thos. H. Wiggin, Consulting Engr., 415 Lexington Ave., New York City.

Wm. H. Brush, Deputy Chief Engr., Dept. Water Supply, Gas and Elec., Municipal Building, New York City.

W. C. Hawley, Chief Engr. and Gen. Supt., Pennsylvania Water Co., Wilkinsburg, Pa.

E. E. Wall, Water Commissioner, 312 City Hall, St. Louis, Mo.

F. A. Barbour, Hydraulic and San. Engr., Tremont Building, Boston, Mass.

National Fire Protection Association

C. W. Mowry, Director, Factory Mutual Laboratories, Boston, Mass.

U. S. Bureau of Standards

I. J. Fairchild, Bureau of Standards, Washington, D. C.

Underwriters' Laboratories

A. W. Claussen, Asst. Engr., Underwriters' Laboratories, Chicago, Ill.

American Society for Testing Materials

Richard Moldenke, Consulting Metallurgist, Watchung, N. J.

S. R. Church, Technical Adviser, The Barrett Co., New York City.

New England Water Works Association

F. A. McInnes, Consulting Engr., Boston, Mass.

C. W. Sherman, Consulting Engr., Boston, Mass.

W. R. Conard, Burlington, N. J.

Manufacturers Standardization Society of the Valve and Fittings Industry

C. R. Wood, 400 Chestnut St., Phila., Pa.

American Cast Iron Pipe Co.

W. D. Moore, President, Birmingham, Alabama.

J. B. Clow and Sons

Kent S. Clow, Vice-President, Chicago, Ill.

Glamorgan Pipe and Foundry Co.

A. M. Campbell, Lynchburg, Va.

Lynchburg Foundry Co.

W. G. Hammerstrom, Lynchburg, Va.

National Cast Iron Pipe Co.
A. M. Ford, Asst. Engr., Birmingham, Ala.
R. D. Wood and Co.
Walter Wood, 400 Chestnut Street, Phila., Pa.
Warren Foundry and Machine Co.
Shellman B. Brown, Supt., Phillipsburg, N. J.
U. S. Cast Iron Pipe and Foundry Co.
N. F. S. Russell, Pres., Burlington, N. J.
D. P. Hopkins, Vice-Pres., Burlington, N. J.
D. B. Stokes, Gen. Sales Mgr., Burlington, N. J.

WILLIAM THOMPSON SEDGWICK MEMORIAL

In recognition and perpetuation of the services and ideals of Professor W. T. Sedgwick and in love for the man, his friends desire to create a permanent remembrance. A group of these friends began the accumulation of a fund for the permanent endowment of a Sedgwick Memorial Lectureship. The lectures are to be given at least once a year upon some subject in biology or public health. The three lectures in this series to date have been given by E. B. Wilson, W. H. Welch and W. J. V. Osterhout.

A second group of friends have met and formulated plans for a Sedgwick Memorial Medal to be awarded not oftener than once a year for distinguished service in public health. This plan was laid before the Governing Council of the American Public Health Association and through this body the Association voted to accept the responsibility for administering the funds and awarding the medal through an appropriate committee.

There are already some funds on hand for these projects. A further sum of $15,000 is needed to place both endowments on a permanent basis. The Committees feel that friends and admirers of Professor Sedgwick will desire to make a contribution to this fund. It is possible to give to either project or to designate the division of one's contribution if so desired. If no division is indicated gifts will be equally divided in support of both of undertakings.

Subscriptions should be forwarded to William Thompson Sedgwick Memorial Fund, 370 Seventh Ave., New York City.

REGULATIONS ON CROSS CONNECTIONS—NEW YORK STATE DEPARTMENT OF HEALTH

At a meeting of the Public Health Council held November 12, 1925, Chapter VII of the Sanitary Code[1] was amended by adding

[1] The State Sanitary Code does not apply to New York City.—*Editor.*

thereto three new regulations to be known as Regulations 15-a, 15-b and 15-c, to take effect July 1, 1926, and to read as follows:

Sanitary Code—Chapter VII

MISCELLANEOUS

Regulation 15-a. Certain cross-connections between water supplies not permitted. No officer, board, corporation or other person or group of persons, owning or having the management or control of any potable water supply furnished to any municipality or water district, shall permit after July 1, 1926, any physical connection between the distribution system of such supply and that of any other water supply, unless such other water supply is regularly examined as to its quality by those in charge of the potable water supply to which the connection is made and is also found to be potable. This prohibition shall apply to all water distribution systems either inside or outside of any building or buildings.

Provided, that, where such physical connections now include two gate valves with indicator posts, two check valves of the Special Factory Mutual Fire Insurance design or equivalent with drip cocks and gauges for testing, all located in a vault of water-tight construction accessible for ready inspection, the date of discontinuance may be extended until July 1, 1928.

Regulation 15-b. Permissible arrangements where dual supplies are used. If a potable water supply is used as an auxiliary supply delivered to an elevated tank or to a suction tank, which tank is also supplied with water from a source with which cross-connections are not permitted by regulation 15-a, such tank shall be open to atmospheric pressure and the potable water supply shall be discharged at an elevation above the high water line of the tank.

Regulation 15-c. Non-potable water in industrial plants to be rendered unavailable for drinking. Wherever a potable public water supply is available, no other supply shall be used or rendered available for drinking and for other personal or domestic purposes in any industrial plant, unless such other supply is approved by the local health officer. If no such public water supply is available, the water for drinking or for other domestic purposes shall be of safe, sanitary quality approved by the local health officer. If the water supply for industrial or fire protection purposes is obtained entirely or in part from a source not approved for drinking purposes, this supply shall be distributed through an independent piping system having no connection with the systems for drinking and for other domestic use, and the outlets shall be so arranged as to be inaccessible for drinking.

SOCIETY AFFAIRS

4-STATES SECTION

The 4-States Section had a luncheon at the Bellevue-Stratford Hotel, on Thursday, December 17, 1925.

After the luncheon was over, there was an informal meeting presided over by Carleton E. Davis, former President of the Section.

A paper was read by S. M. Van Loan, of the Philadelphia Water Department, concerning the work of his department during subway construction.[1]

After the reading of the paper a few remarks were made by H. F. Huy, President of the Association, and B. C. Little, Secretary.

Following these remarks, an able discussion of Mr. Van Loan's paper was carried on by W. W. Brush, who gave some of his personal experiences with the work in New York City and V. B. Siems. Mr. McCaleb, President of the Pennsylvania Water Works Association, also made a short address.

IOWA SECTION

The eleventh annual meeting of the Iowa Section, was called to order by Chairman Max Levine at the Hotel Julien, Dubuque, at 10:20 a.m., Tuesday, December 2. C. E. Douglas, City Manager of Dubuque, welcomed the Section to the city on behalf of Mayor Alberson, who was unable to attend on account of sickness. Chairman Levine responded to Mr. Douglas's address. Thirty seven members were present.

The New Manual of Water Works Practice of the American Water Works Association, was discussed by Jack J. Hinman, Jr., Arthur T. Luce, J. W. McEvoy, Joseph W. Straub, Frank Lawlor, R. H. Holbrook and C. R. Knowles.

The Flushing of Water Mains was discussed by Frank Lawlor, William Molis, J. W. McEvoy, John W. Pray, J. C. Jensen, Arthur T. Luce, C. D. Hays, H. C. Hawkins, E. D. Brown, and Thomas J. Skinker.

[1] Journal, March, 1926, page 288.

Algae Troubles During the Past Summer, was discussed by Jack J. Hinman, Jr,. Max Levine, J. W. McEvoy, C. D. Hays and R. H. Holbrook.

The meeting adjourned at 12:00 noon.

The Section reconvened at 2:00 p.m. and listened to the reading of papers, as folows:

1. "A New Water Supply for the City of Oneida, New York," by Dr. Nicholas Knight, Professor of Chemistry, Cornell College, Mount Vernon, Iowa.

2. "Softened Water for Industrial and Municipal Use," by Mr. W. D. Collins, Chemist in Charge, Quality of Water Division, United States Geological Survey, Washington, D. C. Discussed by L. I. Birdsall, R. H. Holbrook, C. R. Knowles, A. T. Luce, Paul C. Laux and J. P. Hanley.

3. "The Cause and Prevention of Red Water,"[2] by Paul C. Laux, National Lime Association, Chicago, Illinois. Discussed by L. I. Birdsall, J. P. Hanley, C. O. Bates and R. H. Holbrook.

A fifteen minute recess was taken at this point, after which the members of the Section resumed the further discussion of Round Table topics.

"Auxiliaries for Steam Operation of Pumping Plants" was discussed by A. T. Luce, P. F. Hopkins and H. F. Blomquist.

"How Often Should Coagulation Basins Be Cleaned," was discussed by L. I. Birdsall, F. G. Gilkison, Frank Lawlor, J. P. Hanley, J. C. Jensen and H. F. Blomquist.

The session ajourned at 4:50 p.m.

A special dinner was held in the dining room of the Julien Dubuque Hotel at 6:00. At 8:00 p.m. the public meeting, which was scheduled on the program for the Chamber of Commerce rooms, was opened in a special room provided at the Julien Dubuque Hotel. There was an attendance of about eighty-five, the greater number of whom were those in regular attendance at the meeting, and from out of the city. The following papers were given:

1. "Keeping the Water Works Working," Charles R. Henderson.

2. "Water and Health," Don M. Griswold, State Commissioner of Health, Des Moines, Iowa.

3. "The Need for Water Supply Data,"[3] N. G. Grover, Chief Hydraulic Engineer, United States Geological Survey, Washington, D. C.

[2] Journal, March, 1926, page 271.

[3] This Journal, page 400.

The session adjourned at about 10:00 p.m.

The Tuesday morning meeting was opened by Chairman Levine at 9:40 a.m. with fifty-six members and guests present. Papers were read as follows.

1. "Water Softening by the Hot Process, With and Without the Use of Alum." A. M. Buswell. Discussed by C. R. Knowles and C. O. Bates.

2. "The Rehabilitation of the Marshalltown Water Works," Arthur T. Luce, Discussed by A. M. Buswell, P. F. Hopkins, G. C. Habermeyer, and G. F. Gilkison.

(At this point Chairman Levine turned the chair over to Vice Chairman, H. V. Knouse, of Omaha, Nebraska.)

3. "Laboratory Control of the Chemical Treatment of Missouri River Water," Kenneth C. Armstrong, discussed by A. M. Buswell, W. A. Kivell, G. F. Gilkison, H. V. Knouse, L. I. Birdsall and C. R. Knowles.

4. "Ground Water Resources of Illinois,"[4] G. C. Habermeyer, discussed by L. I. Birdsall, J. P. Hanley and C. R. Knowles.

The following committees were appointed by Chairman Levine to report at the business session during the afternoon:

Nominating Committee: Charles R. Henderson, Chairman, William Molis and C. D. Hays.

Resolutions Committee: Frank Lawlor, Chairman, R. H. Holbrook and Thomas J. Skinner.

Auditing Committee: E. B. Black, Chairman, and L. L. Hezzelwood.

The session adjourned at 12:30 p.m.

The session reconvened at 2:00 p.m. and proceeded to the reading of papers as follows:

1. "Water Supply Conditions in Missouri" by Geo. W. Putnam. Discussed by C. O. Bates, H. V. Pedersen, H. V. Knouse, G. F. Gilkison, L. I. Birdsall, R. H. Holbrook and J. P. Hanley.

2. "The Determination of Dissolved Oxygen and Biochemical Oxygen Demand in Studies of Stream Waters" by Jess M. Holderby, Discussed by C. O. Bates, H. V. Pedersen and Max Levine.

3. "The Pollution of Streams by Wastes from Canneries and Dairies in Iowa" by John H. Buchanan, Associate Professor of Sanitary Chemistry, Iowa State College, Ames, Iowa. Discussed by Max Levine.

[4] Journal, March, 1926, page 234.

4. "Laying Cast Iron Mains"[5] by Homer V. Knouse, Discussed by C. R. Knowles.

5. "Financial Reports of Water Works Operation" by H. F. Blomquist, discussed by Max Levine and A. T. Luce.

The paper entitled "Placarding Public Water Supplies on Tourist Highways" by Earl L. Waterman was read by title in the absence of the author.

The Section then went into business session. The nominating committee brought in the following ticket:

For Chairman, Homer V. Knouse.

For Vice Chairman, J. W. McEvoy.

For Directors: Thos. J. Skinker, C. D. Hayes.

The ticket as presented was unanimously elected.

The resolutions committee brought in the following resolutions:

1. "The Iowa Section of the American Water Works Association in convention assembled at Dubuque, Iowa, requests all members of the Section to call the attention of the Members of Congress to the injustice of compelling employees of Municipal Water Departments to pay the federal income tax, when all other municipal officers and employees are exempt therefrom."

2. "*Be it Resolved:* That the Iowa Section of the American Water Works Association extends its thanks to Don. M. Griswold, A. M. Buswell, N. C. Grover, W. D. Collins, J. M. Holderby, P. C. Laux, Nicholas Knight, J. H. Buchanan, and G. C. Habermeyer for their contribution to the program of the Iowa Section."

3. "*Resolved:* That the Iowa Section of the American Water Works Association extends its thanks to the City of Dubuque, to its Council, City Manager, City Solicitor, and Water Board for the assistance and encouragement offered the members of the Section in connection with the eleventh annual meeting."

4. "*Resolved:* That the Iowa Section of the American Water Works Association extends it special thanks to J. W. McEvoy, Superintendent of the Water Works, Dubuque, Iowa, for his efforts and his work in making the eleventh annual meeting of the Section a success."

5. "*Resolved:* That the Iowa Section expresses its regrets at the fact that Dr. James Alberson, Mayor of Dubuque, was unable to be present at the meeting and address the Section as originally planned. And be it further resolved that the Section express to Mayor Alberson its sincere wishes for his speedy recovery from his injury."

6. "*Be It Resolved:* That the Iowa Section of the American Water Works Association express its appreciation to the management of the Hotel Julien Dubuque for courtesies extended in connection with the eleventh annual meeting of the Section."

7. "*Be it Resolved* by the Iowa Section of the American Water Works Association that stream pollution studies along the line outlined by Don M.

---

[5] Journal, February, 1926, page 129.

Griswold in his address before the Section are necessary to the public good, and that the intensive conduct of the studies initiated on the Iowa rivers should be continued for the protection of our streams and for the furtherance of and the safeguarding of the public health."

8. "*Be it Resolved* by the Iowa Section of the American Water Works Association that the publication recently produced by the Standardardization Council of the Association under the Chairmanship of George W. Fuller, is heartily endorsed as a suitable Manual of Water Works Practice, and that it is recommended to the careful study of the membership of the Section and all other persons who are interested in the economical and efficient operation of water works plants."

The Auditing Committee, by E. B. Black, Chairman, reported that they had examined the books of the Secretary-Treasurer and found them correct.

The session then adjourned at 5:30 p.m.

At 6:00 p.m., the entertainment and dinner given by the manufacturers' agents took place. The members of the Section enjoyed an excellent dinner and an interesting program of songs and other specialities which had been provided. The appreciation of the Section was recorded by means of a vote.

On Friday morning Chairman Levine called the Section to order at 10:00. The following talks were given:

1. "Coöperation of City Water Department With Health Department Under City Manager Form of Government," by Dr. D. C. Steelsmith, Health Officer, City and County of Dubuque, Dubuque, Iowa. Discussed by H. F. Blomquist, Jack J. Hinman, Jr., Max Levine and C. O. Bates.

(At this point Dr. Levine turned the chair over to Homer V. Knouse.)

2. "The City Manager Plan at Dubuque" by M. H. Czizek, City Solicitor, Dubuque, Iowa. Discussed by P. F. Hopkins and Max Levine.

3. "The History and Present Situation of the Dubuque Water Works System," by J. W. McEvoy, Discussed by H. F. Blomquist, George E. Shoemaker, P. F. Hopkins and Homer V. Knouse.

Topic Number Eight of the Round Table Discussion, "Proper Spacing of Fire Hydrants"[6] was discussed by F. H. King, P. F. Hopkins, William Molis, Homer V. Knouse, Frank Lawlor, and H. F. Blomquist.

W. W. DeBerard told the Section of the desire of the Chicago

[6] Journal, March, 1926, page 224.

members that the 1927 meeting of the American Water Works Association be held in Chicago. Desirability of such a meeting in connection with the water works situation in Chicago was discussed by several members. It was moved by H. V. Knouse, seconded by Frank Lawlor, that it was the sense of the Iowa Section meeting that the 1927 meeting of the American Water Works Association should be held in Chicago, and that the Secretary of the Iowa Section should be instructed to notify the Secretary of the Association and the Convention Committee of that body concerning this matter. The motion was carried.

The meeting adjourned at 12:25 p.m.

In the afternoon the members of the Section were taken to see the various parts of the Dubuque water supply system. The parties were conducted by J. W. McEvoy, the Superintendent of the Water Plant. The cars used were furnished by the Chamber of Commerce of Dubuque. Unfavorable weather conditions prevented the seeing of the beautiful scenery on the bluffs of the Mississippi to the best advantage. This was disappointing to the members of the Section and to the local committee. One hundred and one members and guests attended the meetings.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Iron Incrustation in Water Pipes: the Responsibility of Iron Algae. David Ellis. Water and Water Eng., **27**: 352–354, 1925. Hard nodules found in water pipe were separated from pipe wall by tar coating giving impression that material came from water rather than from pipe and was probably due to algae. Although the organisms were present and iron sufficient for their growth was contained in the water, formation of nodules in this way could not be demonstrated. Tar coating was found pervious to water and iron came from pipe. Soft slimy deposits may be due to bacteria and iron from water. Ellis has never found hard nodules in wood pipe.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Venturi Flume and Effect of Contractions in Open Channels. Alex. H. Jameson. Water and Water Eng., **27**: 271–273, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Silting of the Modder River. John A. Caskie. Water and Water Eng., **27**: 354–355, 1925. Storage capacity for Bloemfontein water supply is seriously reduced due to silting. Attempts have been made to remove much of silt by increasing velocity during flood times.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Bacteriological Purification of Drinking Water with Alkaline Hypochlorites and Liquid Chlorine. D. F. Ricart. Memorial de Ingenieros del Ejercito, November, 1924. General and comprehensive paper dealing with permanent and military installations.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Lucknow Water Supply. Anon. Water and Water Eng., **27**: 263, 1925. Purification equipment consists of 3 m.g.d. Patterson rapid sand filters and old (slow sand?) filters. Maximum daily capacity is about 9 m.g.d.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Chesterfield, England, New Water Works. Chas. Boldry. Water and Water Eng., **27**: 257–263, 1925. Engineering description of ground water project to supplement existing gravity surface supply.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Preparation of Endo's Medium. Norman McL. Harris. Military Surgeon, **57**: 280, 1925. Levine's formula does away with meat extract which is a bothersome substance. Basic fuchsine contains rosaniline and pararosaniline. Other fuchsines are irregular. Hydrogen ion concentration of 7.4 to 7.6 is best. Any peptone which will give good result in Levine's formula is satisfactory. Formula: K_2HPO_4 3.5 grams; Difco Peptone 10 grams; washed and dried agar 15 grams; lactose C.P. 10 grams; distilled water 1000 grams. To each 100 cc. of above add Na_2SO_3 anhydrous 0.25 gram; basic fuchsine (containing rosaniline and parasrosaniline) 10 per cent filtered alcoholic solution, 3.5 cc.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Goiter and Drinking Water. Gerald M. Flood. Water and Water Eng., **27**: 54–55, 1925. Considers that actual cause of goiter is bacterial and that it is spread by sewage polluted waters.—*Jack. J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

A California Oil Well (Deep Record). Anon. Science, **62**: 366, 1925. Statement based on report of Dr. F. P. Vickery regarding Miley Oil Co's No. 6 well at Athens, Los Angeles County, California. Oil was produced at 7591 feet. Well has following records: (1) 7591 feet, deepest hole ever drilled. (2) Deepest oil well. (3) Landed 41-inch casing at 7591 feet. Longest casing. (4) Cemented through perforations at 7305 feet. (5) Took formation cores at 7570 feet and recovered perfect samples of good oil sand. Drilled with rotary tools in 230 working days, averaging 33 feet per day. Cost of drilling, labor, and material $21.60 per foot or $164,000. Producing 150 bbls. 37°Be. oil with 20 per cent salt water. Gas lift is used as pumping at the necessary depth was not considered practical.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Taste Factor in Drinking Water. Lancet, July 11, 1925, pp. 76–77. Two kinds of tastes likely to be found in city water; (1) chlorinous, (2) iodoform. That of iodoform can be produced by 1 part of phenol in 1000 million parts of water. There is sufficient phenol in air of large towns to supply this amount. Chief taste preventers are organic matter, $KMnO_4$, and NH_4 compounds. Filtration after chlorination might reduce taste. Particulars are given of cost of treatment for taste removal by Sir A. C. Houston.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Mechanically Slaked Lime, an Important Product for Water Softening. Anon. Water and Water Eng., **27**: 209, 1925. Irregularity of composition of CaO due to air slaking, stone, grit, etc., makes it more difficult to use than mechanically slaked lime. Latter increases 30 per cent in weight on slaking, but free moisture is less than 0.25 per cent. More accurate dosing is possible. Cost is slightly higher due to process, bagging, etc. There is no wastage.—*Jack H. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Causes of the Appearance and Diffusion of Cholera: the Rôle of Carriers of Germs and the Results of Preventive Vaccination. Pottevin and Abt. Bul. mens. office internat d'hyg. publ., **17**: 864-896, 1925. Water borne epi-

demics are exceptions. Merchandise, except green vegetables, is not incriminated. Carriers are important. Bibliography of 85 titles.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Supervision Over the Safety of Chicago's Water Supply. ARTHUR E. GORMAN, Proc. Ills. Eng. Soc., **40**: 57–63, 1925. Water is obtained through six cribs in Lake Michigan 2 to 4 miles from shore. Calumet river is chief source of contamination. Backing up of Chicago river occasional menace. Dumping of dredged materials into lake for fill and sewage from lake vessels also important. Hourly tests for free chlorine are made to check adequacy of treatment at each station. 3000 pounds liquid Cl are applied to 800 million gallons on daily average.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Pulverized Coal as Applied to the Steam Boiler Plant. W. E. EAST, Proc. Illinois Eng. Soc., **40**: 75–80, 1925. First used in 1899 in cement industry, but not successfully applied to steam boilers till 1916 at Parsons, Kan., plant of M. K. T. Ry. First central station use at plant of Milwaukee Elect. Ry. and Light Co. Present specifications require 65 per cent of coal to pass 200 mesh sieve. Formerly finer grinding was required. Formerly thought it was necessary to dry coal to 1 per cent moisture, but now dry only to 5 to 8 per cent moisture. Lignite containing 24 per cent moisture will be used at Denver. Advantages: (1) high boiler efficiency, (2) ability to burn high and low grade fuels with approximately same efficiency, (3) ability to burn liquid, solid, or gaseous fuel in same furnace, (4) low banking and stand-by losses, (5) ability to carry high overloads for long periods, (6) ease of adapting to automatic control.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

A Water-Borne Typhoid Epidemic at Aegion, Greece. GEORGE SP. JOANNIDES. La Grèce medicale, **27**: 10, 1925; Bul. mens. office internat. d'hyg. publ., **17**: 907–908, 1925. An epidemic of 128 cases and 2 deaths in November 1924. Water of aqueduct was polluted at point of entrance to reservoirs. Distribution of water was stopped, repairs made, and reservoirs treated with lime. Prophylaxis by hypodermic injection having been refused, the vaccine (1,200 millions B. typhosus, 600 millions each of para A and B per cc.) was administered before breakfast on three consecutive days in doses of 30 drops. None of those treated developed the disease.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Observations on the Working of Slow Sand Filters. V. GOVINDA RAJU, Water and Water Eng., **27**: 350–352, 1925. Custom of wasting water from maturing filters is very wasteful, since water could be chlorinated and used. Resanded beds which give bad water for a time after resanding could receive chlorinated raw water and effluent could be used. There is no deterioration of quality of effluent with high loss of head provided violent fluctuation of rate of filtration does not occur. In Bengal life of filter is too short (2–6 wks.) Chlorination of raw water and suppression of algae should prolong use. Filters usually operate much slower than necessary. A drop of 2 inches per hour was noted when 4 inches would have been better. Wasteful regulation of

settling basins is common. Chlorination of raw water applied to slow sand filters is to be preferred to chlorination of filtered water.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Is Stream Pollution Necessary? C. M. Baker, Proc. Eng. Soc. Wis., **17**: 77–84, 1925. It is not feasible to do away with stream pollution entirely under present civic and industrial conditions, but it should be controlled and kept within reasonable limits.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Deep Well Pumping. Leon A. Smith. Proc. Eng. Soc. Wis., **17**: 86–92, 1925 Pumping experience at Madison, Wis. Recommendations: (1) If suction lift is less than 20 feet under maximum pumping, pump by suction. (2) If group of wells is to be pumped and extreme distance between wells is 6000 feet or less and total lift less than 200 feet, use an air lift and central compressor station. (3) If an individual well is to be pumped directly into mains use an electrically driven deep well pump provided storage is ample and size of well permits pump installation. If storage capacity is not available a gasoline engine or other standby unit is advisable. In each case consideration should be given all methods.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Report on the Installation of Sewers and the Propagation of Worm Infestations in British Guinea. H. Khalil. J. Helminthology, **2**: 175–190, 1924; Sanitation Supplement, Tropical Disease Bulletin, **1**: 45, Mar. 1925; Bul. mens. office internat. d'hyg. publique, **17**: 1014–1016, 1925. In England and Europe most thought is given to bacterial content of sewage and waters. Worms, including hookworm, and protozoa are very important in tropics. Hookworm larvae can pass through filter paper and through the human skin. Filtration is probably not effective against them. Septic tank action does not always kill hookworm larvae.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Welded Steel Pipe Protected Inside and Out by Reinforced Concrete. A. Bonna. La Technique Sanitaire, **20**: 80–88, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Supplying the Communes of the Canton of Vaud, Switzerland, with Potable Water. Roux. La Technique Sanitaire, **20**: 88, 1925. Out of 388 communes, all but 62 are served by public water supplies.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Cemeteries and Cremation. Fr. Messerli. La Technique Sanitaire, **20**: 65–71, 1925. Discusses decomposition of cadavers and relation to nature of soil of burying ground, ground water height, and hygiene. Cremation is favored on ground of economy as well as on that of hygiene.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The conduits for supplying potable water to the cities of Flanders and the Belgian coast, Le genie civil, Sept. 20, 1924; La Technique Sanitaire, **20**: 97–98, 1925. Water derived from carboniferous limestones south of Liège by

galleries 1.95 m. x 0.9 m. x 4 km. with large zone of protection is carried to a large number of Belgian communities by a conduit 51 km. long, of which 25 km. is in tunnel, 17 km. in trench and 9 km. in siphons.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Société Nacionale des Distributions d'Eau de Belgique, Its Purpose Duty, Organization and Operation. Hachez. La Technique Sanitaire, **20**: 127–131, 1925. A coöperative intercommunal association established by law in 1913 in which the nation takes a part, provides part of the capital, and names one half the board of direction and the director general. The constituting act is reprinted.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Report on the Water Softening and Purification Works for the Year 1924. Chas. P. Hoover. Supplement to the City Bulletin, Columbus, Ohio, 1924, 29–38. Hardness of water of Scioto River was reduced from average of 299 p.p.m. to 99 p.p.m. Raw water was 10 per cent harder than average for last 16 years. Lime, soda ash, alum and Cl were the chemicals employed in treatment. 8700 million gallons were treated at a cost for chemicals of $20.81 per million gallons.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Seventeenth Annual Report of the Division of Sewage Disposal. C. D. McGuire. Supplement to City Bulletin, Columbus, Ohio, 1924, 39–43. Operation of sprinkling filters was not necessary until July on account of rains and high water. During the year 4571 million gallons of sewage were treated. The dose on the filters was at the rate of 2.64 m.g.d. The mean dosage was 4.57 m.g.d. and the filters were in service 58 per cent of the time. The imhoff tanks removed 96 per cent by volume of the settleable solids and 60.6 per cent of the total suspended solids. The detention period was 4.6 hours. The consumption of dissolved O was reduced 38.5 per cent by the tanks. The filters removed 23 per cent of the suspended solids of the tank effluent and decreased the consumption of dissolved O 77 per cent and produced 3.4 p.p.m. N as NO_2 and NO_3 in effluent. The whole system removed 69.7 per cent of the total suspended solids and reduced the consumption of dissolved O 85.7 per cent. Wet sludge is produced to amount of 7.6 cubic yards per million gallons, or 2.6 cubic yards per million gallons on dry basis. Filters were designed for 20 m.g. per day but are now handling a maximum of 37.5 m.g.—*Jack J. Hinman, Jr.*

Swimming Pools. Wesley Bintz. Playground, **19**: 259–262, 1925. Maximum daily attendance in average town is about 7 per cent of population, and maximum attendance at one time is 2 per cent. Recommends round or oval pool on account of less length of wall and lessened temperature stresses as compared to rectangular pool. Footings at least 3 feet below ground surface and sub-drainage are necessary in order to prevent frost damage. Average pool is about 60 per cent wadable, but larger area of shallow water is desirable. Length rather than too great width is advantageous in designing pool of definite area. This assists guards. Overhead lights are required to assist life guards, if pool is to be opened at night.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Safe Water for the Highways. Anon. Public Health (Michigan), 3:1 306–308, 1925. Details of work of State Health Department in 1925. Three types of signs were posted; one was a large sign advising use of approved water supplies; other two were for individual supply, noting its character. Sign for unsafe sources was in red and white, for others, gray and black.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Economics Resulting from the Rational Use of Conduits in Cast Iron, Steel, and in Reinforced Concrete for Transporting Water and Gas. J. Gilbert, La Technique Sanitaire, 20: 187–195 and 209–214, 1925. Dangers of leakage into and from water mains and of collection of escaped gas under pavements are discussed. Considerable space is given to various classes of joints, especially one designed by the author.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Purification of Water Supplies on Field Service, as Retrospect. Col. Sir William Horrocks. J. Royal Army Medical Corps, 45: 167–189, 1925. Summary by the expert of British Army on quality of water.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Analyses of Rainfall from a Protected and an Exposed Gauge for Sulfur, Nitrates and Ammonia. E. M. Johnson. J. Am. Soc. Agron., 17: 589, 1925. Work undertaken to evaluate influence of bird droppings on analysis of rain waters as collected from gauges. Bird droppings from an old loft showed 0.78 per cent S on dry basis of which 0.58 per cent was water-soluble. Actually found less S in water from exposed gauge than in that from protected gauge, due to biological action of bird droppings. More ammonia was found in the exposed gauge.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Sewage Pollution of Drinking Water for Cattle and Its Effect on Them. A. Levie. Veterinary Record, 5: 692–693, 1925. Drinking sewage polluted water causes loss of appetite, unthriftiness, drowsiness, weariness, scouring, and sometimes vomiting. Septic swellings of throat occasionally occur. Cattle kept solely on water containing high proportion of crude sewage will die in about six months. Recovery on clean water requires about 3 to 6 months. Author thinks that toxins of sewage are important, and that cattle drinking sewage laden water are more susceptible to tuberculosis, Johnee's disease, and contagious abortion.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Use of Potassium Permanganate in Drinking Water for Poultry. Silvert Ericksen. J. Am. Vet. Med. Assn., 67: 496, 1925. Added to pink color. Recommended as very effective.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Effects of Drinking Water Polluted with Crude Oil. Anon. No. Am. Veterinarian, 6: 13–14, 1925. Legal action in Illinois for loss of two cows was lost because of failure to prove that crude oil was cause of poisoning.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Observations on the Relation of Oil Pollution to Livestock Losses. A. H. Gish. North American Veterinarian, 6: 51–52, 1925. Poisoning not uncommon from oil or salt from wells. Oil is injurious when consumed in large quantities, or when it comes into contact with large area of the body. In small quantity damage is doubtful unless long continued. Some animals become intoxicated, bloat, and may, or may not, belch up oil. Pupils dilate, respiration accelerates, and heart beats fast and weak. Muscular incoördination precedes death. Mild cases recover but never put on flesh well. Post mortem shows high state of inflammation of digestive tract, liver, kidneys, etc. Presence of considerable quantity of oil is conclusive evidence. Oil which has not lost its volatiles by exposure is likely to cause blistering and cracking of the skin. The salt water contains carbonates as well as NaCl.—*Jack J. Hinman. Jr.* (*Courtesy Chem. Abst.*)

Rapid Filters of the Stuttgart, Wurtemberg, Water Works. Baer. E. des Vereins deut. Ingenieure, June 6, 1925; Le Genie civil, **87**: 339, 1925. Water from the Neckar is submitted to prefiltration, put through sand filters and chlorinated.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Notes on the Control of Water Weeds. A. A. Hansen. J. Am. Soc. Agron., **17**: 119–120, 1925. May be cut in ponds, lakes and ditches with a hand knife, sickle or scythe. For large amounts a submarine saw may be used. This is a thin ribbon-like flexible saw operated by two men, one on each bank. Chains and wire may also be used. A weed cutting launch is used by the Toronto park board. Fencing in and grazing sheep help to keep banks clean. Swans and ducks nip shoots and keep down growth. Sodium arsenite and other highly poisonous chemicals are not recommended. Copper sulfate in amount not over 1 pound per 125,000 gallons may be used. In Manitoba where wells are not practical holes are dug for the collection of rain water. $CuSO_4$ is used in these occasionally with good results.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Chemical Purification of the Boiler Feed Water of Locomotives on the Paris-Lyons-Marseilles System. Vignal. Rev. générale des Chemins de fer, May, 1925; Le Genie civil, **87**: 67–8, 1925. Lime soda process is used.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The "Filtrator" Apparatus for the Prevention of Scaling of Boilers. Anon. Le Genie civil, **84**: 410, 1924. Is not a filter, but an apparatus by means of which steam extracts mucilaginous material from flaxseed and returns with it to boiler. Emulsion formed is claimed to coat particles of precipitate and prevent formation of adherent scale.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Local Water Supply Fails: (Emergency Chlorinator Makes Temporary Supply Safe. Anon. Health News (N. Y.), **2**: 182, 1925. Leak in storage reservoir threatened water famine in Conisteo, Steuben County, N. Y., on Oct. 19th. Chlorination of water of some contaminated wells supplied need.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Carries Typhoid Quarter of Century. Anon. Health News (N. Y.), **2**: 184, 1925. Boarding house keeper was found responsible for 26 cases of typhoid fever. Of 12 cases since 1918, all but one have developed in other communities, mostly in New York City.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

On Structures which Develope in Certain Culture Media and Resemble Colonies of Microorganisms. P. P. LAIDLAW. Brit. J. Exptl. Pathology, **6**: 36–39, 1925. On serum agar colony-like masses which seemed to grow and allow transfer were found to be due to separation from the media of Ca and Mg soaps.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Correlation of Sulphite Reduction Test with Other Tests in the Bacterial Examination of Water. W. J. WILSON and E. M. BLAIR. J. Hyg., **24**: 111–119, 1925. Special medium is made of glucose agar (3 per cent agar) to each 100 cc. of which is added 1 cc. $FeCl_2$ 8 per cent solution; 0.6 cc. NaOH 10 per cent solution; 20 cc. Na_2SO_3 20 per cent solution. Forty cubic centimeters of water are mixed with 100 cc. medium and poured into large Petri dish. Layer of melted sulphite agar is then poured over hardened mixture to keep out air. Certain bacteria such as B. typhosus and B. enterditis Gaertner give deep black colonies. Most B. coli are unable to discolor media. B. welchii and some other forms give dark colored colonies. Bacteria responsible for vegetable decay are in general not sulphite reducers.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

A Note on the Effect of Dyes on Bacterial Growth. F. M. BURNET. Australian J. Biol. and Med. Sci., **11**: pt. 2, 77–82, 1925. There is close similarity between results of bacterial growth where fuchsin was added to agar plates and in plates exposed to light for H_2O_2 production tests. Fuchsin may interfere directly or indirectly with production or utilization of H_2O_2 by the organisms. Probably there is injury to mechanism for utilization of H_2O_2. Growth is sometimes possible with massive inoculation and impossible with a lighter one [cf. F. M. Burnet, *Australian J. Biol. and Med. Sci.*, **11**: pt. 2, 65–76 (1925)].—*Jack J. Hinman. Jr.* (*Courtesy Chem. Abst.*)

Bacillus Typhosus Morphologically Compared with Certain Bacilli Present in Natural Waters. LUCIUS NICHOLS, and EDWIN BURGESS. Ceylon J. Sci., Sect. D, Med Sci., **1**: pt. 2, 47-56, 1925. It was found that B. typhosus could be distinguished morphologically from B. coli and any of 40 bacilli isolated from water. Cultures for comparison were grown on nutrient agar containing 0.5 per cent added NaCl, on similar agar containing 1 per cent NaCl and on similar agar containing no added NaCl. The 40 bacilli isolated from water were capable of producing acid and gas from lactose broth in 33 cases, and capable of producing acid but not gas in 6 cases. A plea for more careful morphological study of the organisms is made.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Note on Determination of Temporary Hardness in Water. W. R. ATKIN and A. GARDNER. J. Soc. Leather Trades Chemists, **7**: 87–90, 1923. From Chem. Abst., **17**: 2023, June 10, 1923. Use of methyl orange for this deter-

mination requires clearly defined color for end point, and perceptible amount of acid is required to cause color change. Bromophenol blue changes color between pH 2.8 and 4.6 with sharp end point at 3.8. Alizarin, used in boiling solution, has range of color change near true neutrality and is extremely sensitive to acids. Preliminary titration is made and then second one in which most of acid required is added and solution boiled before alizarin paste is added. Stock solution of acetic acid and sodium acetate of pH value of 3.8 is made to facilitate obtaining correct shade. Good agreement is obtained with alizarin and bromophenol blue titrations, but end point is clearer and titration more convenient with latter indicator.—*R. E. Thompson.*

Hydrogen Sulfide Formation at the Bottom of the Lake of Onega. K. K. Gilzen. Bull. acad. sci. Russie, 1918, Series VI, 2232–40. From Chem. Abst., **17**: 2023, June 10, 1923. Formation of hydrogen sulfide at bottom of Lake of Onega was observed during dredging investigation. Samples of slimes collected at points where hydrogen sulfide was found were of creamy consistency, yellowish gray when dry, and contained about 6.5 per cent humus matter. Composition, dry basis, was: silica 52.6 per cent, alumina 8.94, ferric oxide 9.08, and sulfur 0.3. Organic matter contained large quantities of detritus and diatomacea. Formation of hydrogen sulfide was due to bacterial decomposition of inorganic sulfates and organic material containing sulfur. There was total exclusion of light, constant temperature of 4°, and pressure of 4–8 atmospheres.—*R. E. Thompson.*

Carbon Dioxide Springs in the Territory of Montepulciano. Gaetano Castelli. Rass. min. met. chim. **58**: 14–5, 1923. From Chem. Abst., **17**: 2023, June 10, 1923. Natural carbon dioxide spring at Montepulciano in Sant' Albino region described. The fissures are filled with slightly opalescent water, through which the gas issues, causing appearance of boiling, though water is only slightly above 0° and carbon dioxide 5-10°. Several hundred cubic meters of carbon dioxide per day are evolved with average composition of: carbon dioxide 95.40 per cent, oxygen 0.33, nitrogen 3.13, combustible gas 0.14, and hydrogen sulfide trace.—*R. E. Thompson.*

Water for Use in Retting Fibers. Gottfried Kränzlin. Faserforchung, **2**: 126–50, 1922. From Chem. Abst., **17**: 2054, June 10, 1923. Chemical analysis fails to yield information of great significance for evaluation of water supply for use in retting flax, etc. While it is generally agreed that iron and manganese in retting water cause discolorations which are hard to remove by modern methods of bleaching, it was not found possible to set maximum limit for concentration of these elements. Similarly hard water is generally condemned, but analysis of highly praised Lys river water show it to be rather hard. Complete analyses of 24 waters used in retting operations given. Iron, expressed as ferric oxide, varies from 0 to 3.1 p.p.m. and total hardness (German scale) from 1.5 to 24°.—*R. E. Thompson.*

The Testing of Durability and Rust-Preventive Properties of Paints. Rudeloff. Mitt. Materialsprüfungsamt., **39**: 232–40, 1913. From Chem. Abst., **17**: 2057, June 10, 1923. Suggested methods outlined.—*R. E. Thompson.*

Basic Aluminum Sulfate. F. S. Williamson. J. Phys. Chem., **27**: 284–9, 1923. From Chem. Abst., **17**: 2089, June 20, 1923. When 2–4 molecules of sodium hydroxide are added to 1 molecule of potassium alum, composition of precipitate is invariable, analysis indicating basic sulfate of approximate composition: $Al_2(SO_4)_3 \cdot (Al_2O_3)_4 \cdot 15H_2O$. Compound $(Al_2O_6H_6)_2 \cdot H_2SO_4$ obtained by Schlumberger by addition of 5 molecules of potassium hydroxide to 1 of potassium alum (cf. Bull. soc. chim. 13, 41 — 1895) was mixture due to addition of excess potassium hydroxide. Above compound loses less than 10 per cent of its water over concentrated sulphuric aid at room temperature, but nearly all water is evolved at 150. Less than one-third is reabsorbed at lower temperatures, indicating that compound is not reversible hydrate.—*R. E. Thompson.*

A Method For the Determination of Dissolved Carbon Dioxide. F. G. Hall. J. Biol. Chem., **55**: 751–5, 1923. From Chem. Abst., **17**: 2123, June 20, 1923. Modification of apparatus of Van Slyke and of Van Slyke and Stadie (C. A. **11**: 2208; **16**: 728) adapted for use with large volumes, of liquid. Gases are liberated by repeated evacuations (10) and volume measured before and after absorption with potassium hydroxide.—*R. E. Thompson.*

The Volumetric Determination of Calcium. A. Vürtheim and G. H. C. van Bers. Chem. Weekblad, 20, 68, 1923; J. Grossfeld. Ibid, **20**: 209–10, 1923. From Chem. Abst., **17**: 2092, June 20, 1923. Objections are raised to method of G. (C. A. **17**: 1399) and further experiments described which appear to substantiate some of G.'s claims.—*R. E. Thompson.*

Determination and Correction of the Hardness of Water. Ed. Justin-Mueller. Industrie chimique, **10**: 111–2, 1923. From Chem. Abst., **17**: 2158, June 20, 1923. Soap test for determining hardness, not differing essentially from standard method, described. Temporary hardness is eliminated by addition of proper amount of sodium hydroxide, which forms sodium carbonate, and latter reduces permanent hardness by amount equivalent to temporary hardness, so that sodium carbonate equivalent only to difference between permanent and temporary hardness need be added.—*R. E. Thompson.*

Industrial Water. G. Paris. Chimie et industrie, **9**: 439–53, 1923. From Chem. Abst., **17**: 2159, June 20, 1923. General description of methods of purifying water, especially for boilers.—*R. E. Thompson.*

Rapid Determination of Total Iodine in Sulfur Waters. J. Dubief. Ann. fals., **16**: 80–2, 1923. From Chem. Abst., **17**: 2159, June 20, 1923. To 50 or 100 cc. of sample in 100 cc. glass-stoppered graduated cylinder add 4 cc. 10 per cent sodium bicarbonate and potassium permanganate (25 g. per liter) to pink coloration, and then 5 cc. in excess. Cool below 10°, add 2 cc. of carbon bisulfide and 5 cc. concentrated sulfuric acid dropwise, avoiding any rise in temperature, and decolorize with 3 per cent hydrogen peroxide (about 2 cc.). If sample contains more than 5 times as much bromine as iodine add drop of

0.1 N potassium thiocyante, shake, and repeat, alternating additions of potassium thiocyanate (avoiding excess) and shakings till yellow color of bromine is discharged. Shake till violet color of iodine in carbon bisulfide develops, and compare with standards prepared similarly. If there is less than 5 times as much bromine, addition of thiocyanate can be omitted. Chlorine does not interfere. By addition of thiocyanate, 0.05 mgm. of potassium iodide mixed with 0.1 g. of potassium bromide was determined. Method is sensitive to 0.02 mgm. per portion tested. Latter should not contain over 0.5 mgm. If temperature is kept below 10°, method is as accurate as sodium nitrite method.—*R. E. Thompson.*

Determination of Combined Carbonic Acid (Carbonate Ion) in Sulfur Waters. F. Touplain and J. Dubief. Ann. fals., **16**: 76–80, 1923. From Chem. Absts., **17**: 2159, June 20, 1923. To 200 cc. of water in 300 cc. Erlenmeyer flask add slight excess lead peroxide, shake 10–15 minutes, add 10 cc. 3 per cent hydrogen peroxide, heat gradually to 45°, maintain 30 minutes, allow to cool, filter, evaporate 100 cc. filtrate to dryness, take up with water, liberate carbon dioxide with sulphuric acid potassium bichromate mixture, and absorb in soda-lime.—*R. E. Thompson.*

Softening of Industrial Waters by Means of Permutite. D. Marotta. Giorn. chim. ind. applicata, **5**: 10–12, 1923. From Chem. Abst., **17**: 2159, June 20, 1923. Discussion of action of permutite upon hard waters, with analysis of sample of product and description of filters, their functioning and cost of maintenance.—*R. E. Thompson.*

Purification of Water with Lime. II. J. Smit. Meded. Burgerl. Geneesk. Dienst. Nederland. Indie, 1921, **2**: 111–89; Expt. Sta. Record, **47**: 288; cf. C. A., 15, 1050. From Chem. Abst., **17**: 2159, June 20, 1923. Action of quicklime, due to its high alkalinity, is much more marked than that of alum. The alkaline water is neutralized with small amount of carbon dioxide or by thorough aëration.—*R. E. Thompson.*

Fuel Consumption of the Different Types of Furnaces. W. Trinks. Fuels and Furnaces, **1**: 1, 41–2, 1923. From Chem. Abst., **17**: 2182, June 20, 1923. Table given showing British thermal units per gross ton heated and average thermal efficiency of 18 types of furnaces.—*R. E. Thompson.*

The Stein Recuperative Furnace. W. B. Chapman. Fuels and Furnaces, **1**: 1, 41–2, 1923. From Chem. Abst., **17**: 2182, June 20, 1923. Furnace described which is claimed to save fuel consumption by preheating air. Table given showing fuel saving by preheating air to temperatures from 200 to 1900° F., and for different excesses of air.—*R. E. Thompson.*

Water for the Dyehouse. Wm. C. Dodson. Textile Colorist, **45**: 156–7, 1923. From Chem. Abst., **17**: 2193, June 20, 1923. Decaying vegetable matter in reservoir gave rise to sufficient carbon dioxide in purified water to attack iron of piping and cause trouble with spots on fabrics.—*R. E. Thompson.*

Residual Waters of Cokeries. R. Durand. Bull. soc. pharmacol., **30**: 216–9, 1923. From Chem. Abst., **17**: 2186, June 20, 1923. Dead fish on surface of Marne indicated presence of poison, probably from coke ovens. Analysis proved water from condenseries in cokeries, before purification, contained 0.085–0.17 gram hydrogen sulfide and 0.07–0.12 gram hydrocyanic acid per liter. Water from drain, after purification, contained 0.005–0.007 gram hydrogen sulfide and 0.0021–0.04 gram hydrocyanic acid per liter. Water of river 15 meters below entrance of drain from purification plant contained no measurable amount of either impurity. If water is properly purified with chlorine no trace of these compounds remains.—*R. E. Thompson.*

Behavior of Ozone. E. H. Riesenfeld. Z. Elektrochem., **29**: 119–21, 1923. From Chem. Abst., **17**: 2210, July 10, 1923. Physical data on ozone given.—*R. E. Thompson.*

The Reaction Between Hypochlorite and Potassium Iodide. I. M. Kolthoff. Rev. trav. chim., **41**: 615–26, 1922. From Chem. Abst., **17**: 2245, July 10, 1923. Interesting data on reaction which may be employed for evaluating calcium hypochlorite and other hypochlorites.—*R. E. Thompson.*

Testing of Bleach Liquor. R. E. Gegenheimer. Textile Colorist, **45**: 167–8; Color Trade J., **12**: 131–2, 1923; Paper Mill, **47**: 9, 14, 16 (1923). From Chem. Abst., **17**: 2248, July 10, 1923. Description of simple apparatus for approximate determination of available chlorine in bleaching solutions by hydrogen peroxide gas-buret method, in which pressure generated by oxygen evolved gives direct reading in grams available chlorine per liter.—*R. E. Thompson.*

Corrosion Tests on Metals and Alloys in Acid Water from Coal Mines. W. A. Selvig and Geo. M. Enos. Carnegie Inst. Tech. Coöperative Mining Courses Bull., **4**: 1922. From Chem. Abst., **17**: 2259, July 10, 1923. Results of tests of corrosion of various metals and alloys by three acid mine waters.—*R. E. Thompson.*

Electric Welding of Cast Iron. Lebrun. Rev. métal, **20**: 248–9, 1923. From Chem. Abst., **17**: 2259, July 10, 1923. To obtain satisfactory electric weld of gray cast iron, means must be provided for continuous addition of carbon to replace that burnt by arc, otherwise weld would be transformed into white cast iron.—*R. E. Thompson.*

Seasonal Variations in the Dissolved Oxygen Content of the Water of the Thames Estuary. Wm. Butler and J. H. Coste. Biochem. J., **17**: 49–58, 1923. From Chem. Abst., **17**: 2291, July 10, 1923. Water is appreciably supersaturated with oxygen even though in free contact with air. Marked alkalinity and supersaturation occur together. Still weather tends to preserve supersaturation. When water is agitated by wind supersaturation disappears rapidly. Oxygen of supersaturation is but a proportion, and probably small one, of volume set free by marine photosynthesis. It has always been realized

that sea acts as great stabilizer of carbon dioxide content of air by reason of bicarbonate-carbonate equilibrium. It appears equally efficacious in maintaining, by continual contributions, constant proportion of oxygen in air.—*R. E. Thompson.*

Pollution of Drinking Water by Intestinal Bacteria. ERIK BONDO. Nord. hyg. Tids., 2, **13**: 1921; Absts. Bact., **5**: 512. From Chem. Abst., **17**: 2335, July 10, 1923. No difference was found in acid production by B. coli from warm-blooded or cold blooded animals, but indol production was negative with latter and positive with majority of former.—*R. E. Thompson.*

Methods of Drinking-Water Examination. W. OLSZEWSKI. Chem.-Ztg., **47**: 273, 1923. From Chem. Abst., **17**: 2336, July 10, 1923. Volumetric estimation of sulfate by benzidine method is advised. Manganese may be detected by following method, using same sample for determination of ammonia. Treat 300 cc. of sample with sodium bicarbonate and allow to stand several hours. Decant 200 cc. for ammonia determination, thoroughly shake remainder and filter. Treat residue with benzidine acetate solution and dilute to 300 cc. Blue color shows presence of manganese. Iron salts do not interfere. Benzidine acetate solution is prepared as follows: grind 20 grams benzidine with 20 cc. water, transfer to liter measuring flask and add about 750 cc. water and 50 cc. acetic acid and dilute to mark. Shake, allow to stand one day and filter. Solution should be kept in dark flask. Test is sensitive to 1 part in 125,000,000. Qualitative tests for manganese were also made with *o*-tolidin, but iron oxidation products also produced blue color. For estimation of manganese, Marschall test (Hyg. Wassers, 1915) is recommended.—*R. E. Thompson.*

Hydrogen-Ion Concentration of Natural Waters in Relation to Disease. W. R. G. ATKINS. J. State Med., **31**: 223–6, 1923. From Chem. Abst., **17**: 2336, July 10, 1923. Natural waters vary from pH 5 for bog pool to about pH 8.3 for stream saturated with calcium bicarbonate. Reaction of natural waters, normally between pH 6.8 and 8.0, is favorable for existence of Vibrio cholerae and bacilli of typhoid group. In contrast to acid limits of Dernby and others, suggestion is made that water may be rendered safe for drinking by increasing pH to 10.5 by addition of ash derived from vegetable matter, which is rich in sodium and potassium carbonates. Necessity of stating temperature when limiting and optimal values are given for growth of various organisms is noted.—*R. E. Thompson.*

Heteromorphism of Calcium Carbonate. Marble, Synthetic and Metamorphic. MAURICE COPISAROW. J. Chem. Soc., **123**: 785–96, 1923. From Chem. Abst., **17**: 2376, July 20, 1923. Investigation of colloidal and gelatinous state of calcium carbonate observed by NEUBERG and REWALD (cf. C. A. 3, 155) and transformation of various forms of calcium carbonate indicate: (a) Formation of hydrocalcite, calcite, aragonite and precipitated chalk by double decomposition of alkali carbonates and soluble calcium salts is effected in stages—diffusion, solution, gelatinous form, and solid; final form

of solid depending on experimental conditions. (b) Gelatinous phase obviated by slow diffusion may, under favorable conditions, be prolonged practically indefinitely. This form, which exists in aqueous medium, has shorter range of existence and can be less definitely characterized than colloidal calcium carbonate prepared by Rose (cf. Pogg. Ann. **42**: 354). It may be regarded as unoriented molecular aggregates of hydrocalcite formed in course of forced transformaton of initial liquid magma into hydrocalcite. **Heteromorphism of Calcium Sulfate. Alabaster and Its Synthesis.** Ibid. 796–9. Neither state of temporary supersaturation nor gelatinization occurs in formation of calcium sulfate, probably because it shows no tendency to form varieties of hydrates of greater hydration than gypsum.—*R. E. Thompson.*

The Aëration of Quiescent Columns of Distilled Water and of Solutions of Sodium Chloride. W. E. Adeney, A. G. G. Leonard and A. Richardson. Phil. Mag., (6) **45**: 835–45, 1923. From Chem. Abst., **17**: 2377, July 20, 1923. Aëration of quiescent bodies of fresh or salt water under natural conditions is effected by process of mixing of exposed layer to depths of 10 feet at least. Mixing is caused by downward "streaming" of constantly changing exposed layer probably to depths much greater than 10 feet. Streaming takes place more uniformly in salt than in fresh water; is largely dependent on cooling by evaporation from surface, and is more rapid at 10° or above. Optimum concentration of salt appears to be about 1 per cent.—*R. E. Thompson.*

The Ageing of Thiosulfate Solutions. E. Abel. Ber., **56B**: 1076–9, 1923. From Chem. Abst., **17**: 2404, July 20, 1923. Great number of contradictions regarding stability of standard sodium thiosulfate solutions occur in literature. Use of distilled water containing trace of copper, which catalyzes oxidation of thiosulfate to tetrathionate by atmospheric oxygen, suggested as one possible cause of deterioration, and use of water distilled from glass advised.—*R. E. Thompson.*

Corrosion of Rust-Proofed Iron and Steel. W. P. Wood. Chem. Met. Eng., **28**: 769–72, 1923. From Chem. Abst., **17**: 2409, July 20, 1923. Iron and steel, uncoated and after having undergone various rust-proofing processes, were tested for corrosion in slowly moving water saturated with oxygen. Presence of oxygen apparently causes exaggerated initial corrosion in iron and low-carbon steel. Small amount of chlorine in tap water causes slight increase in corrosion rates of immersed metals. Copper content of iron and steel does not affect rate of corrosion. Different surface conditions of metal tend to become equalized over period of time and corrosion rates to become steady and uniform when large amounts of oxygen are present. Oxygen does not appear to increase pitting. Galvanizing seems to be best means of preventing corrosion.—*R. E. Thompson.*

The Titration of Culture Media. L. Michaelis. Z. Immunitäts, **32**: 194–203, 1921. From Chem. Abst., **17**: 2433, July 20, 1923. H-ion concentration of media determined with 0.3 per cent m-nitrophenol, using wooden block comparator in which compensation is made for color of broth by placing

tube of same behind color standards. Autoclaving ordinary broth does not change pH. Diluting with salt solution also has no effect on pH, owing to buffering effect of peptone and phosphates.—*R. E. Thompson.*

Comparative Investigation of Mineral and Plant Oils Used for Lubricating Purposes. M. A. Rakusin. Petroleum Z., 19: 454–6, 1923. From Chem. Abst., 17: 2464, July 20, 1923. Viscosity at different temperatures and other physical data on various lubricating oils given.—*R. E. Thompson.*

Development of the Uses of Liquid Chlorine in Germany. Henri Muraour. Chimie et industrie, 9: 806–8, 1923. From Chem. Abst., 17: 2464, July 20, 1923.—*R. E. Thompson.*

Barium in the Harrogate Waters. A. Woodmansey. Lancet, 1923, 1: 22; Pharm. J., 110: 30, 1923. From Chem. Abst., 17: 2465, July 20, 1923. Presence of 3.51–6.91 parts per 100,000 of barium and 1:140,000 and 1:190,000 of dissolved barium sulfate in Harrogate spring waters is noted. In very low concentrations barium exerts marked stimulating action on all forms of muscular tissue and causes gradual but sustained rise in blood pressure.—*R. E. Thompson.*

The Sulfur Content of Rain Water. L. N. Erdman. Soil Science, 14: 363–7, 1922. From Chem. Abst., 17: 2465, July 20, 1923. Sulfur content of rain water in Iowa under rural conditions was 3.32 p.p.m.—*R. E. Thompson.*

Effects of Water Treatment on the Reduction of Maintenance Expense and Increasing Capacity of Locomotives. W. C. Smith. J. Western Soc. Engineers, 28: 220–3, 1923. From Chem. Abst., 17: 2465, July 20, 1923. Mo. Pacific R. R. operates 81 softening plants, 36 of which are of intermittent type and 45 of continuous type. Six additional plants are under construction. Large savings are realized.—*R. E. Thompson.*

The Effect of Gambusia Affinis on the B. Coli Index of Pollution of Water. L. C. Havens and Sophie A. Dehler. Am. J. Hyg., 3: 296–9, 1923. From Chem. Abst., 17: 2465, July 20, 1923. Normal intestinal flora of Gambusia (top minnows) in Alabama waters is represented by B. pyocyaneus and an unindentified, aërobic, lactose-fermenting, spore-forming bacillus. B. coli was not found in intestinal tract. When Gambusia was added to polluted waters B. coli disappeared, due largely to inhibitory influence of B. pyocyaneus hence B. coli index may be rendered unreliable guide to pollution by these minnows.—*R. E. Thompson.*

Some Factors Affecting the Evaporation of Water from Soil. E. A. Fisher. J. Agr. Sci., 13: 122–43, 1923. From Chem. Abst., 17: 2466, July 20, 1923. Subject is developed from physico-chemical and mathematical standpoint, with detailed experimental data.—*R. E. Thompson.*

The Manufacture of Bleaching Powder. Otto Nydegger. Industrie chimique, 10: 151–3, 1923; World's Paper Trade Rev., 79: 1822, 1824, 1923. From Chem. Abst., 17: 2477, July 20, 1923.—*R. E. Thompson.*

Effect of Carbon Dioxide Variation on Boiler Efficiency. W. P. Crews. Elec. World, 81: 1218, 1923. From Chem. Abst., 17: 2493, July 20, 1923. Relationship between superheat and carbon dioxide and efficiency at various boiler ratings is shown. It is advisable to maintain maximum carbon dioxide, keep superheaters clean and let superheat come where it will. Gain in efficiency due to high superheat is not as reliable as that obtained with good combustion in boiler and high carbon dioxide content.—*R. E. Thompson.*

Corrosion and Other Deposits in Gas Services. B. Richardson. Gas. J., 162: 348-50, 1923. From Chem. Abst., 17: 2493, July 20, 1923. Corrosion is primarily due to combined action of water, carbon dioxide and oxygen on ironwork of mains.—*R. E. Thompson.*

The Titration of Hypochlorous Acid. A. Schleicher. Z. anal. Chem., 62: 329–35, 1923. From Chem. Abst., 17: 2543, August 10, 1923. Clarens (C. A. 8: 3279) claimed that chlorine peroxide vapors are formed in titration of sodium hypochlorite or bleach solutions with arsenious acid. Experiments with ordinary titration with iodo-starch paper as indicator have failed to confirm C.'s assertion and addition of potasium bromide as indicator, as recommended by him, was found unsatisfactory. Mechanical stirring was found better than hand stirring. Good agreement was obtained by electrometric titration against buffer solution.—*R. E. Thompson.*

Estimation of Magnesium in Sea Water by the Use of a Single Drop of Sea Water. G. Denigès. Compt. rend., 175: 1206–8, 1923. From Chem. Abst., 17: 2543, August 10, 1923. Series of standards is prepared by adding 0-14 drops of 0.0005 N. magnesium sulfate solution to different tubes, each of which is diluted to 5 cc., and treated with 1 drop of 3 per cent sodium chloride, 0.5 cc. 10 per cent potassium iodide and 2 drops freshly prepared sodium bromate. Color obtained with sea water similarly diluted and treated with potassium iodide and sodium bromate is matched with these standards.—*R. E. Thompson.*

The Bursting of Steam Boiler Tubes During Use. Walter Ritter. Feuerungstechnik, 11: 39, 1922. From Chem. Abst., 17: 2550, August 10, 1923. Martensitic structure at point of rupture showed that tube had been heated at some time to above 700 and suddenly cooled. Contributory causes were corrosion by sulfur dioxide and uneven wall thickness.—*R. E. Thompson.*

The Disinfecting Action of Lime Water. Jan Smit. Chem. Weekblad, 20: 263, 1923. From Chem. Abst., 17: 2591, August 10, 1923. Addition of 74 p.p.m. of lime kills cholera vibrio within 30 minutes.—*R. E. Thompson.*

The Effects of Certain Concentrations of Hydrogen Ions upon Intestinal Bacteria. K. Scheer. Z. Immunitäts., I Abt., Orig., 33: 36–42, 1921; Absts. Bact., 6: 106; cf. C. A., 16: 3921. From Chem. Abst., 17: 2592, August 10, 1923. Data on final pH produced by intestinal bacteria in bouillon containing sugar and on H-ion concentrations which are fatal to these bacteria. After

3 days growth in broth containing 5 per cent lactose, with original reaction of pH 6.7, B. coli produced final reaction of pH 5. Resistance to bactericidal action of acid varies with time of exposure. In 24 hours B. coli was killed in fluid at pH 4.7, and B. typhosus at pH 5. These figures are said to be fairly characteristic of species of organism, being definite value in each case.—*R. E. Thompson.*

The Bacteriophagy and the Self-Purification of Water. P. C. Flu. Proc. Acad. Sci. Amsterdam, **26**: 116–21; Tijdsher. vergelijk. Geneeskunde, **8**: 218–33, 1923. From Chem. Abst., **17**: 2623, August 10, 1923. Bacteriophagy plays no part in self-purification of water.—*R. E. Thompson.*

Purification of Waste Waters By Means of Clay. Carré. Halle aux Cuirs, **2**: 40, 1923. From Chem. Abst., **17**: 2624, August 10, .1923. System of treatment outlined. Cf. C. A. **16**: 3989.—*R. E. Thompson*

Chlorine, Chlorine Hydrate, and Waste Waters. Raymond Fournier. Papeterie, **45**: 374–8, 418–25, 1923. From Chem. Abst., **17**: 2643, August 10, 1923. Waste liquors are discussed from standpoint of stream pollution.—*R. E. Thompson.*

Control of Water Consumption in the Chemical Industries. Anon. Chem.-Ztg., **47**: 481–4. 1923. From Chem. Abst., **17**: 2758, August 20, 1923. Several water meters described.—*R. E. Thompson.*

Mechanism of So-Called Dry Corrosion of Metals. U. R. Evans. Trans. Faraday Soc. (advance proof), 1923. From Chem. Abst., **17**: 2699, August 20, 1923. Researches are described showing effect on "apparently dry" corrosion of presence of volatile liquids, of contact with dissimilar metal, and of humidity. Phenomena are best explained if it is considered that electrochemical action occurs in adherent (usually invisible) film of moisture. Volatile electrolytes increase conductivity of film and thus accelerate corrosion. Where there is tendency to produce hygroscopic corrosion products, more moisture is absorbed and film thickness increased; in some cases metal soon sheds liquid copiously and serious corrosion results.—*R. E. Thompson.*

The Use of Sodium Chloride as a Standard in the Determination of Halogens in Sea Water. J. Giral and F. A. Gila. Compt. rend., **176**: 1729–30, 1923. From Chem. Abst., **17**: 2687, August 20, 1923. Series of gravimetric analyses shows that presence of sodium, magnesium and calcium sulfate in sea water does not sensibly affect determination of halogens as halide.—*R. E. Thompson.*

Acid-Resisting Alloys for Use in Mine Water. Geo. M. Enos. Coal Age, **23**: 685–8, 1923. From Chem. Abst., **17**: 2700, August 20, 1923. Results of tests of resistance to corrosion of many different alloys in slowly moving mine water given.—*R. E. Thompson.*

A Method for the Detention of Phenols Produced by Bacteria. William H. Bell. J. Inf. Dis., 29: 424–8, 1921. From Chem. Abst., 17: 2720, August 20, 1923. Acidified fluid medium is subjected to steam distillation, and presence of phenols in distillate is indicated by production of red color when diazotized p-nitroaniline in alkaline solution is added. Method will show on blank determinations distinct yellowish red color with phenol diluted 1:1,000,000. Phenol in concentrations of 1:500,000 can easily be detected in culture mediums.—*R. E. Thompson.*

Occurrence of Iodine in Nature. Th. von Fellenberg. Mitt. Lebensm. Hyg., 14: 161–240, 1923. From Chem. Abst., 17: 2717, August 20, 1923. Historical sketch given of studies upon iodine from work of Chatin (cf. Compt. rend. 30–39, 46, 50, 82 (1850–1876) to isolation of thyroxin by Kendall (cf. C. A. 14: 407). Relationship between amount of iodine in drinking water and prevalence of goiter and cretinism is discussed. Special analytical methods given for determination of iodine in water.—*R. E. Thompson.*

Calculation of Charts for Flue Gas Analysis. Paul Schrieber. Arch. Wärme-wirtschaft, 3: 231–3, 1922. From Chem. Abst., 17: 2774, August 20, 1923. Description of theory and construction of various simple charts for determining excess air and completeness of combustion from flue gas analyses.—*R. E. Thompson.*

The Relations Between the Radioactivity, the Temperature and the Sulfuration of the Springs of Bagnerès-de-Luchon. Explanatory Hypothesis. Adolphe Lepape. Compt. rend., 176: 1908–10, 1923. From Chem. Abst., 17: 2819, September 10, 1923. Springs emerging from schists are more radioactive than those from granite. In general, radioactivity varies inversely with temperature and sulfuration, but in few cases it varies directly with sulfuration. There are two types of water: deep water, hot, with high sulfuration and little radioactivity and surface water, cold, not sulfurated, but radioactive. Nature of spring waters is determined by how much these two types are able to mix.—*R. E. Thompson.*

The Importance of Chlorine in Water Purification. H. Selter and W. E. Hilger. Gesundh. Ing., 46: 126–8, 1923; Gas u. Wasserfach, 66: 292. From Chem. Abst., 17: 2927, September 10, 1923. Chlorination results in complete destruction of bacteria, disproving idea that bacteria in chlorinated water regain power of causing infection.—*R. E. Thompson.*

The Radioactivity of the Springs of Some Stations of the Pyrenees (Bagnères-de-Luchon, Vermet, the Escaldes, Thuês) and of the Central Plateau (the Bourboule, Royat, Saint-Nectaire, Sail-les-Bains). Adolphe Lepape. Compt. rend., 176: 1702–5, 1923. From Chem. Abst., 17: 2820, September 10, 1923. Table given showing Ra Em per liter in more active mineral waters of France.—*R. E. Thompson.*

The Clarifying Plant for the Purification of Waste Water by Gas at the New Foundry of the Mansfeld Copper Shale Works. F. H. Schilling. Wasser,

18: 51–2; Chem. Zentr., 1922, IV: 360. From Chem. Abst., 17: 2847, September 10, 1923. Purification of waste water by gas, separation of suspended matter, which consists chiefly of metallic dust and oily and tarry constituents, is facilitated by decreasing velocity.—*R. E. Thompson.*

Microstructural Aspects of Metals and Alloys Corroded by Acid Mine Water. R. J. Anderson and Geo. M. Enos. Carnegie Inst. of Tech. Coöperative Mining Courses, Bull. 5; From Chem. Abst., 17: 2852, September 10, 1923. Results given of microscopic examination of corroded test specimens of metals and alloys which had been immersed in acid mine waters and previously reported on in Bulletin 4.—*R. E. Thompson.*

Corrosion of Copper by Salt Solutions. W. Müller. Z. Metallunde, 14: 286–95, 1922. From Chem. Abst., 17: 2852, September 10, 1923. Copper is rapidly corroded by sea water and by sodium and magnesium chlorides, with formation of green basic chloride which readily detaches itself from the metal and therefore does not form protective coating. Weak solutions of magnesium and calcium sulfate corrode copper very slowly, metal becoming gradually covered with white precipitate containing bluish green flakes of basic sulfate.—*R. E. Thompson.*

Alloys Resistant to Mineral Acids and Their Application to the Construction of Apparatus. B. Waeser. Apparatebau, 34: 129–33; Chem. Zentr., 1922, IV, 222. From Chem. Abst., 17: 2857. Physical properties, method of working, and applications of Krupp V2A Steel (chromium-nickel steel) and silicon alloys of iron discussed.—*R. E. Thompson.*

The Bearing Metal "Thermit." G. v. Hanffstengel. Z. Ver. Deut. Ing., 67: 455, 1923. From Chem. Abst., 17: 2858, September 10, 1923. New bearing metal put out by Th. Goldschmidt A. G., containing nickel, lead, tin and other metals, is claimed to be equal, or superior, to white metal and to melt at least 120° lower, i.e., 480° compared with 600°.—*R. E. Thompson.*

Effect of Mineral Salts on the Growth of Bacteria. C.-E. A. Winslow and Margaret Hotchkiss. Sci. Proc. Soc. Am. Bact., Dec., 1921; Absts. Bact., 6: 4, 1922. From Chem. Abst., 17: 2899, September 10, 1925. Ammonium chloride has no stimulating action on bacterial growth, and exerts inhibitive action in molar concentration. Other salts studied stimulate growth in high dilution and inhibit in low dilution. Molar concentrations at which these respective actions are apparent on B. coli are: calcium chloride 0.01 and 0.5, magnesium chloride 0.05 and 0.5, strontium chloride 0.1 and 1.0, sodium chloride 0.5 and 3.0, potassium chloride 0.5 and 4.0.—*R. E. Thompson.*

Information Concerning Some Microbiological Works in Progress. Giacomo Rossi, E. Calendoli C. Colizza and E. Palmieri-Nuti. Ann. scuola agr. Portici., (2), 15: 1-12, 1920. From Chem. Abst., 17: 2901, September 10, 1923. **IV. New Studies on Bacillus coli.** Inoculation of peptonized water and Eijkmann's liquid indicate that B. coli is far from being as abundant in soils (even manured) as commonly stated.—*R. E. Thompson.*

Report on Universal Metering for the City of Chicago. MAURY and GORDON. Engr. and Contr., 64: 343–53, 1925. Detailed report shows that installation of meters can stop annual deficits and save huge costs of additional plant.—*C. C. Ruchhoft.*

The Setting of Water Meters. JOHN L. FORD. Engr. and Contr., 64: 361–3, 1925. Conditions to be met, type of setting, and means of assuring efficient service are described.—*C. C. Ruchhoft.*

A Southern Well and Its Screen. J. R. AGNEW. Engr. and Contr., 64: 368–9, 1925. Description, with diagrams, of Clarksdale, Miss., well and pump is given. Screens are placed at three strata in one bore and produce fine yield.—*C. C. Ruchhoft.*

Sewage Disposal Problems in Kansas. ERNEST BOYCE. Munic. and County Engr., 69: 41–44, 1925. General discussion of sewage disposal problems of Kansas.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

The Glass Covered Sludge Drying Bed. WALDO S. COULTER. Munic. and County Engr., 69: 57–60 (1925). The hotbed and greenhouse types of covered sludge drying beds are described. Partition walls so that fresh sludge may be separated from partly dried sludge, proper ventilation and protection of the glass with wire screen for small plants are discussed.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Fridley Conduit, St. Paul Water Works. J. W. KELSEY. Munic. and County Engr., 69: 70–73, 1925. Construction features of 60-inch inside diameter conduit are given. Water is pumped from Mississippi River through this conduit to Charles Lake, a distance of 8 miles. Steel pipe having a semi-rubber base coating was used for first 8150 feet. Balance of conduit was constructed of reinforced concrete poured directly in place, with construction joints every 20 feet.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Notes on Toledo's Water Supply Problem. W. J. SHERMAN. Munic. and County Engr., 69: 133–5, 1925. Data are presented showing the advisability of the Miami and Erie Canal as source of Toledo's water supply.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

The Trend of Purification Plant Design and Operation. WELLINGTON DONALDSON. Engr. and Contr., 64: 371–76, 1924. There has been an improvement in appearance of buildings and grounds and also in interior treatment. Tendency has been toward greater flexibility of operation and adequate metering of water flows, master venturi meters being usually provided either at input or output. Aëration, by various styles of aërators, for removal of odors and of iron, is being used by an increasing number of plants. Preliminary sedimentation before application of coagulant has proven advantageous for plants handling very muddy waters. There is no remarkable improvement in coagulation basin design but there have been improvements in clean-

ing arrangements. Dry feeding devices are gaining popularity. Perforated pipe is leading in popularity for rapid sand filter underdrains. Use of air wash in addition to water wash is almost obsolete. There is great diversity in design of auxiliary filter equipment. Practically all sterilization is now done with liquid chlorine. Value of good records and reports is being realized, and better trained operators are in demand.—*C. C. Ruchhoft.* (*Courtesy Chem. Absts.*)

Survey Shows How Niagara Falls is Receding. Eng. News-Rec., **95**: 636–7, October 15, 1925. Illustrated data given showing rate of recession of Niagara Falls as evidenced by surveys of 1764, 1842, 1875, 1917 and 1925. Study of figures indicate that since 1906 amount of rock excavated annually has been somewhat less than formerly was case, but that maximum lineal recession at apex of Horsehoe is greater than formerly, probably due to diversion of 15 per cent of mean flow by power companies and concentration of flow into limited crest line respectively. Annual recession over period 1764–1925 has averaged 4,820 square feet, and mean rate of recession 4 feet per year.—*R. E. Thompson.*

Mast and Spout Concreting Plant Has Special Features. Eng. News-Rec., **95**: 684–5, October 22, 1925. Illustrated description of concreting plant employed in construction of memorial hospital and medical hall at University of Chicago. Entire area, 299 by 363 feet, and 266 by 45 feet, was served by 3 steel masts with long spouting systems. Two hundred cubic yards of concrete was poured from each tower in 8-hour day. Average of 420 cubic yards was placed daily by means of 3 towers and 21 men.—*R. E. Thompson.*

Two Water Mains in Wide Streets. CALEB MILLS SAVILLE. Eng. News-Rec., **95**: 646–7, October 15, 1925. Advantage of 2 mains on wide streets has become so obvious that in future it is planned to follow this procedure on all wide streets in Hartford, Conn. Examples given of existing applications of this practice. Service pipes are not laid in advance of pavement in Hartford, this being considered impracticable. All services now installed up to and including 2-inch are cement-lined wrought iron; or brass, if applicant pays difference in cost. One-inch cement-lined pipe costs about 25 cents per foot. Charges for making connections and maintenance thereafter, in improved pavement and other locations respectively, are: 1-inch, $75, and $45; 1½-inch, $90 and $60; 2-inch, $105 and $75; 4-inch, $280 and $250; 6-inch, $360 and $330. City claims title to these connections and they are carried as part of plant value, being charged to capital account.—*R. E. Thompson.*

Survey Control in Driving 3-Mile Water Supply Tunnel. RICHARD R. BRADBURY. Eng. News-Rec., **95**: 594–8, October 8, 1925. Detailed description of survey methods employed on 3⅓-mile hard rock tunnel which constitutes part of new 12-mile aqueduct from Pawtuxet River, source of new water supply of Providence, R. I., to present distribution system. Earth dam is under construction on river which will impound 37,000 m.g.—*R. E. Thompson.*

Depreciation on Slip-Jointed Steel Pipe. E. Court Eaton. Eng. News-Rec., 95: 603–4, October 8, 1925. Brief details given of two irrigation systems—Lindsay Strathmore and Terra Bella—in San Joaquin Valley. Pipe used was slip-joint light riveted steel, 4 to 36 inches in diameter, protected by dipping and covering with high grade roofing paper lapped spirally under tension. Location is one where dipped unprotected pipe has very short life. Cost of 180 miles of pipe in two systems averaged $5,450 per mile, and maintenance and repair cost for 6 years 1919-1924 averaged $11.60 per mile. Number of leaks occurred with approach of cold weather due to contraction of slip joints and others developed where protective covering had been damaged during installation.—*R. E. Thompson.*

Mokelumne Water Supply Contracts Let. Eng. News-Rec., 95: 608, October 8, 1925. Contract awards announced totalling $11,751,427, included in which is 85 miles of electrically welded steel pipe to be manufactured in Oakland, Cal. Diameter of pipe will be 60–65 inches, and heads will range up to 380 feet. Samples submitted have shown beyond question possibility of securing welded joints which are 100 per cent efficient. Adoption of this method of manufacture will save East Bay Municipal Utility District $4,000,000.—*R. E. Thompson.*

Power Head Totally Enclosed in Deep Well Pump. Eng. News-Rec., 95: 652, October 15, 1925. Brief illustrated description of pump with power head completely enclosed, manufactured by American Well Works, Aurora, Ill. Recommended for heads up to 600 feet and discharge up to 250 g.p.m.—*R. E. Thompson.*

Further Data on Moccasin Creek Penstock Breaks. Eng. News-Rec., 95: 666–7, October 22, 1925. Discussion of damage sustained by Moccasin Creek power plant on San Francisco's municipally owned and operated Hetch Hetchy project as result of violent water hammer due to failure to open bypass valve which would fill section of pipe between nozzle and main gate valve, before opening main gate valve itself.—*R. E. Thompson.*

Diesel Engine Exhaust Manifold Made of Corrugated Steel. Eng. News-Rec., 95: 695, October 22, 1925. Brief description of large manifold for controlling noise from installation of 6 Diesel engines—2 each of 500, 750, and 1000 h.p.—recently constructed at El Paso, Tex. Manifold is 36 inches in diameter, 104 feet long, and has 50-foot stack. Noise of engines could formerly be heard within 3-mile radius.—*R. E. Thompson.*

St. Cloud, Minn. Eng. News-Rec., 95: 672, October 22, 1925. Mississippi River water is chlorinated and purveyed, but no one drinks it, water from private or community wells being preferred. Sixty per cent of population of 21,300 indicated in referendum that they were satisfied with such procedure, and of other 40 per cent, 60 per cent favor filtration and remainder, softened well water system. Forty pounds pressure is maintained, boosted to 80–100 during fires, and although consumer obtains no culinary supply, all but 200

taps of the 2500 services are metered, charge for water being 20 cents per 1000 gallons. Consumption varies between 1.3 and 5 m.g.d.—*R. E. Thompson.*

Cutting Piling Under Water—Review of Various Methods. Samuel P. Baird. Eng. News-Rec., 95: 601–2, October 8, 1925. Brief outline and discussion.—*R. E. Thompson.*

New Jersey Engineers Study Shore Erosion and Protection. Eng. News-Rec., 95: 598–600, October 8, 1925. Conclusions and recommendations of Bd. of Commerce and Navigation of N. J., re coast protection, reproduced from recently issued report.—*R. E. Thompson.*

Bacterial Life Below Earth Surface. Edson S. Bastin, Frank E. Greer and Gail Moulton. Science, 62: X, November 6, 1925. Of 25 samples of oils and associated waters derived from continuously flowing wells, depths of which were 500–1500 feet, 23 contained an abundance of bacteria of types similar to those present in ocean water.—*R. E. Thompson.*

1400-Foot Submarine Water Main Pulled into Place across Vancouver Harbor. Cont. Rec., 39: 810, August 19, 1925. Brief description of 1400-foot section of 18-inch pipe which was recently successfully pulled into place across bed of First Narrows at entrance to Vancouver Harbor. Section, together with cables and tackle, weighed 330 tons, and entire operation of placing was completed in 12 hours. Actual time pipe was in motion was 69 minutes.—*R. E. Thompson.*

Pocatello, Idaho. Eng. News-Rec., 95: 627, October 15, 1924. Water supply system, municipally owned since 1916, described briefly. Three sources of supply utilized, most distant being Mink Creek from which water is conveyed to city through 10-mile 14-inch wood-stave pipeline. Plans in preparation for storage reservoir of 100-m.g. capacity, which will provide required sedimentation. As watershed is subject to contamination, chlorination is employed. Daily per capita consumption varies from 90 gallons in winter to 167 in summer. Approximately 90 per cent of services metered. Secondary low pressure supply from Fort Hall irrigation project is provided in alleys to serve irrigation purposes only. Property owners charged flat rate of 10 cents per front foot per season for one tap per building lot.—*R. E. Thompson.*

Wave-Actuated Water Hammer Splits 36-Inch Sewer Outlet at Paducah, Ky. A. T. Maltby. Eng. News-Rec., 95: 629, October 15, 1924. Breaks in 350 feet of 36-inch vitrified pipe sewer outlet attributed to water hammer induced by wave action during certain flood stages when pipe was partially submerged.—*R. E. Thompson.*

A New Point in Cold Weather Concreting. C. A. P. Turner. Eng. News-Rec., 95: 1043–4, 1925. Collapse of John Evans Hotel (cf. Eng. News-Rec., 95: 800) may readily be explained by phenomenon of sweating during rise in temperature of concrete chilled, but not necessarily frozen, during early stages

of curing. Concrete may appear to be very hard, yet will soften and sweat during sharp rise in temperature at some subsequent period 3-5 weeks after casting, hardening later and developing working resistance substantially equivalent to normal concrete. This difficulty may be avoided by placing hot and protecting from chilling for first 2-3 days, which may readily be accomplished by heating mix water. Concrete mixed with water of temperature not exceeding 140–150° F., will, in general, be stronger than concrete mixed with cold water.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Construction Methods on Double-Deck Street, Chicago. Eng. New-Rec., **95**: 662–5, 1925. Quality of concrete was controlled by (1) sand inundation and (2) proportioning by fineness modulus and water-cement ratio. Former, in addition to eliminating uncertainty of employing sand of unknown and varying moisture content, increased rate of hydration of cement and also gave mix that flowed more freely with smaller amt. of water.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Sanitary Control in the Development of Ground Water Supplies. Eng. News-Rec., **95**: 626, 1925. Code of principles formulated by committee of Conference of State Sanitary Engineers and adopted at Louisville, Apr. 25, 1925, is given. Subjects dealt with include suction and gravity piping, collecting and storage reservoirs, cross-connections, wells, well supplies, purification, springs, mine water, and infiltration galleries.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Predetermining Concrete Strength on Park Bridges. W. F. Welsch. Eng. News-Rec., **95**: 630–1, 1925. Details are given of successful application of scientific method of designing concrete mixtures based on researches of Abrams. It was found desirable, as factor of safety, to increase slightly quantity of fine aggregate computed, as slight deficiency results in porous concrete.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Was Gem Lake Dam Disintegration Due to Underburned Cement? Lars Jorgensen. Eng. News-Rec., **95**: 606, 1925. Very heavy white deposit of practically pure $CaCO_3$, noticed on downstream face of Gem Lake Dam prior to failure, which had increased to thickness of $\frac{1}{8}$ inch in places and appeared to continue to increase, cannot be explained by study of water, rock, or sand, and must have been due to decomposition of the cement. Small white deposits often seen on dams originating from leaching out of free lime of cement or of laitance accumulated in construction joints, is harmless and should stop when these materials are all leached out. In this case, action continued, cement itself being affected. Although cement employed conformed to usual tests, it may have been somewhat underburned and on point of instability when exposed to severe low temperatures.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Troubles With Waterweed in Open Shallow Reservoir. E. G. Ritchie. Eng. News-Rec., **95**: 638–9, 1925. Troubles experienced in Melbourne, Aus-

tralia, due to growth of waterweed, *Vallisneria spiralis*, in shallow open reservoir are outlined. Growth at first confined to small area suddenly spread to all parts where water was less than 4–5 feet deep. Extension of area affected was later found due to draining of reservoir in late summer, coincidently with seeding season of the plant. Method of control consists in cutting with submarine weed cutting saw operated from 2 boats.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Water-Cement Theory as a Fact in Field Control of Concrete. JOHN G. AHLERS. Eng. News-Rec., 95: 674–5, 1925. Discussion of cement-water ratio method of concrete control, which is shown to be very satisfactory and practical. Grading of aggregate need only be controlled by workability of mix.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Scale-weighing Device Applies the Water-Cement Ratio Theory. Eng. News-Rec., 95: 675–7, 1925. Mechanical device for controlling water-cement ratio, designed by J. G. AHLERS, is described, together with test methods and results of experiments carried out to show (1) that with constant water-cement ratio, strength of concrete was practically constant with varying amounts of aggregate within workable limits; (2) that with constant water-cement ratio, character of aggregate had little effect on strength of concrete; and (3) that with variable water-cement ratio (illustrated graphically), strength could be controlled as desired.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Well Flow Measured by Pitometer Checked by Orifice. JOHN N. BROOKS Eng. News-Rec., 95: 683–4. Brief details are given of measurement of yield of a well by pitometer and orifice methods, which agreed to within 1.2 per cent. Yield of well was approximately 1000 gallons per minute.—*R. E. Thompson.* (*Courtesy Chem. Absts.*)

Woonsocket, R. I. Eng. News-Rec., 95: 717–8, 1925. Water supply of Woonsocket is derived from tributary of Blackstone River and is chlorinated but not filtered, although subject to turbidity. Improvements are at present under way to increase storage capacity.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Sanitary Rules for Installing Well Pumps. Eng. News-Rec., 95: 706, 1925. Sanitary regulations for installing well pumping machinery are given which were formulated by Committee on Sanitary Control of Ground Water Supplies of Conference of State Sanitary Engineers and approved by a number of pump manufacturers.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Pittsfield Mass. Eng. News-Rec., 95: 793–4, 1925. Water supply of Pittsfield is derived from number of lakes and brooks a few miles from city, and stored in 2 reservoirs of 516 and 450 m.g. capacity. The sanitary sewage is pumped to sand filtration beds about 2 miles from city and surface water drains into branches of Housatonic River.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Concrete Pit Structure Subjected to Diverse Stresses. A. E. Wynn. Eng. News-Rec., 95: 762–3, 1925. Description of construction of waterproof reinforced-concrete structure required to withstand possible external hydraulic pressure. For water-proofing, reliance was placed mainly on quality of concrete, with addition of an integral water-proofing compound. Very dense homogeneous concrete was obtained by use of crushed limestone aggregate with crushed stone dust substituted for sand. Construction joints were reinforced with 20-oz. copper baffle strips bent over on each side of joint. Structure has been in use 5 months and has proved entirely satisfactory.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Water Power and Flood Control of Colorado River Below Green River, Utah. E. C. La Rue. U. S. Geol. Survey Water Supply Paper 556: 175 pp., 79 plates, 1925. Valuable contribution to momentous question how best to utilize great resources of Colorado River. An important problem is that of reconciling conflicting needs of flood control, power, and irrigation development, because storage and flow requirements of these interests at different times of the year do not coincide. In introduction to report N. C. Grover writes: "The Geological Survey is not attempting to promote any particular project, but is endeavoring to collect and make available the information needed as the basis for outlining a proper scheme for full development of the river and selecting the site for first development. It recognizes the fact that the final choice of any project will represent a compromise of conflicting interests, in which many factors—engineering, economic, and perhaps political—must be evaluated and given proper weight." Few men, if any, have such first-hand knowledge of problems of development of Colorado as E. C. La Rue, who since 1914 has travelled practically entire canyon section of river. Report gives data on physical characteristics, plan of development, available water supply, power capacity, right of way, accessibility, and relative value of some 50 dam sites, with photographs, maps, geologic cross sections, and area and capacity curves of most of them. La Rue presents plan which he believes will "provide for the maximum practicable utilization of the potential power, maximum preservation of water for irrigation, effective elimination of the flood menace, and adequate solution of the silt problem." Plan proposes construction of 13 dams, creating 42,000,000 acre-feet of storage capacity with 3,383 feet of head available for power development by which it is estimated 3,420,000 continuous horsepower may be developed, allowing for full use of water in upper basin. Flood control is considered to be most urgent problem, for property in excess of $100,000,000 is subject to damage by river. For this purpose La Rue recommends dam in Mohave Canyon near Needles, creating 10,400,000 acre-foot reservoir. Great power development would be in Grand Canyon section with another large storage reservoir of 8,000,000 acre-feet capacity in Glen Canyon above Lees Ferry to regulate flow for power needs. If full use is made of water in upper basin supply will not be enough for all irrigable land in lower basin; and if all irrigable land in Mexico is supplied, about 1,250,000 acres of irrigable land in the United States cannot be watered. Report contains appendix by Raymond C. Moore on geologic features of Grand Canyon, particularly with respect to availability of materials for construction purposes and suitability of rocks at different sites for sustaining dams.—*David G. Thompson.*

NEW BOOKS

The Effects of Ions in Colloidal Systems. MICHAELIS, LEONOR. Baltimore, Md.: Williams & Wilkins Co. Cloth; 5 x 8 in.: pp. 108. $2.50. Reviewed in Eng. News-Rec., 95: 848, 1925.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Bacteriology. THOMAS, STANLEY. New York and London: McGraw-Hill Book Co., Inc. Cloth; 6 x 9 in.; pp. 201. $2.50. Reviewed in Eng. News Rec. 95: 847, 1925.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Les Bains à Travers les Âges. PAUL NEGRIER, PIERRE CALMETTES, and M. MARECHALAR, 8vo, 350 pages, Librairie de la Construction moderne, Paris. Noted in Le Genie Civil 87: 240, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Installer of Pumps. MAURICE LEDOUX, 8vo, 85 pages. Maison Maurice Ledoux et Cie, Bordeaux-Bègles. Noted in Le Genie civil, 87: 28, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Colloidal State and Industry. W. KOPACZEWSKI. Vol. 1, **The Colloid Industries: historical; the Colloid State; Natural and Artificial Colloids.** 8vo, 328 pages, 36 figs. Cha. Béranger, publisher, Paris, and Liège. Noted in Le Genie civil, 87: 280, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Lubricants, Their Nature, Examination and Use. GEORGE LEHR. Translated from the German into French by RICHARD ASHER. 250 pages, 17 figs. Ch. Béranger, publisher, Paris and Liège. Noted in Le Genie civil, 87: 200, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Construction of Wells and Boreholes for Water Supply. J. E. DUMBLETON. London, Crosby Lockwood and Sons, 11s. 6d. net 1925. Reviewed in Water and Water Eng., 27: 343–344, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Report, Water Supply Commission, Pennsylvania, 1921. Engineers interested in hydrographic data, particularly for Pennsylvania streams, will be pleased to know that the 1921 Report of the Water Supply Commission of Pennsylvania, now available for distribution, contains a precipitation map and tables showing the relation between run-off and precipitation.

This is understood to be the first report of its kind containing such information and subsequent reports issued by the Department of Forests and Waters, Water Resources Service, formerly the Water Supply Commission, will contain similar maps and tables.

The precipitation map shows two inch isohyetals for the year ending September 30, 1921, and tables for each of the primary drainage basins in the State show the drainage area for each gaging station; monthly and yearly run-off in second-feet per square mile; yearly run-off depth in inches; yearly precipitation, depth in inches, and the percentage of run-off to precipitation.

The map used for determining the precipitation upon gaging station drainage areas was especially prepared for the purpose. It is drawn to a scale of about ten miles to the inch, covering the entire State of Pennsylvania and those portions of adjoining states which are tributary to Pennsylvania streams. It shows state and county lines, streams and lines for each degree of latitude and longitude.

All known records of precipitation for Pennsylvania were used, those of the Commission, the United States Weather Bureau and private interests. For drainage areas in adjacent states, tributary to Pennsylvania streams, the Weather Bureau records were used.

The yearly precipitation was plotted at the geodetic position of each of 278 stations. Two inch isohyetals and watershed lines for each gaging station were drawn and the mean precipitation for each drainage area was computed from planimetered areas.

The results are probably as accurate as can be obtained with the number of precipitation stations ordinarily operated. During 1925 the Department of Forests and Waters established several additional stations at localities where there was a sparsity of data.

Reports for the years ending September 30, 1922, and 1923, should be available for distribution in a comparatively short time.—*Ralph H. Hosmer.*

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

Vol. 15 MAY, 1926 No. 5

CONTENTS

OFFICERS OF THE AMERICAN WATER WORKS ASSOCIATION (Continued)

Central States Section.—President, JOSEPH W. ELLMS; Vice-President, CHESTER F. DRAKE; Secretary, E. E. BANKSON; Trustees, J. C. BEARDSLEY, D. C. GROBBEL, MENTOR HETZER.

4-States Section.—President, EDGAR M. HOOPES, JR.; Vice-Presidents, V. BERNARD SIEMS, L. VAN GILDER; Secretary-Treasurer, CHARLES R. WOOD; Executive Committee, N. E. BARTLETT, W. H. BOARDMAN, H. D. BROWN, J. W. LEDOUX, GEORGE MCKAY and the officers.

Illinois Section—Chairman, W. R. GELSTON; Vice-Chairman, G. C. HABERMEYER; Treasurer, H. E. KEELER; Trustees, H. M. ELY, L. R. HOWSON, C. M. ROOS.

Indiana Section.—Chairman, J. O. ENDRIS; Vice-Chairman, WM. LUSCOMBE; Secretary-Treasurer, C. K. CALVERT; Assistant Secretary-Treasurer, B. J. T. JEUP.

Iowa Section.—Chairman, HOMER V. KNOUSE; Vice-Chairman, J. W. MCEVOY; Secretary-Treasurer, J. J. HINMAN, JR.; Directors, THOS. J. SKINKER, C. D. HAYS.

Kentucky-Tennessee Section.—Chairman, C. E. DAVIS; Vice-Chairman, W. S. PATTON; Secretary-Treasurer, F. C. DUGAN; Directors, F. W. ALBERT, W. H. LOVEJOY.

Minnesota Section.—Chairman, J. A. CHILDS; Vice-Chairman, FELIX SELIGMAN; Secretary-Treasurer, ARTHUR F. MELLEN; Trustees, OLE FORSBERG, A. D. HORNE, E. MCCULLOH.

Montana Section.—J. F. WILLETT, President; H. B. FOOTE, Secretary-Treasurer.

New York Section.—President, B. B. HODGMAN; Secretary, E. D. CASE; Board of Governors, E. D. CASE, B. B. HODGMAN, F. T. KEMBLE, THADDEUS MERRIMAN.

North Carolina Section.—President, J. O. CRAIG; Vice-President, M'KEAN MAFFITT; Secretary-Treasurer, THORNDIKE SAVILLE; Executive Committee, G. F. CATLETT, E. G. MCCONNELL, H. E. MILLER, A. O. TRUE, W. E. VEST, and the officers.

Wisconsin Section.—Chairman, W. D. LEONARD; Vice-Chairman, EDWARD BROWN; Past Chairman, L. A. SMITH; Secretary-Treasurer, C. M. BAKER; Director, WILLIAM KOEHN.

JOURNAL

OF THE

American Water Works Association

The Association is not responsible, as a body, for the facts and opinions
advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

Vol. 15 MAY, 1926 No. 5

THE WATER WORKS PUMPING STATION[1]

By Robert W. Angus[2]

One of the most important features of a water works system is the pumping plant, and it is often the part to which least attention is paid. If this plant has not been well selected and placed, one is not only confronted with a large expenditure for power and attendance, but may also suffer from lack of water, or from low pressure, at the critical moment.

Not so very many years ago the reciprocating pump was the only type used for this purpose, the source of power being either a steam engine or a hydraulic turbine, and a number of smaller stations are operating in this way yet. Some of the larger stations also use the reciprocating unit to a certain extent, and Toronto still has a large installation of them, although all have been in use for many years and are not new.

VERTICAL TRIPLE EXPANSION ENGINES

Milwaukee has very recently installed a number of vertical triple expansion units of large size, and these have shown very high efficiency, although when reduced to the same steam conditions, the results are identical with those on a similar unit in Toronto, tested by the author in 1906. The Toronto machine established a record for duty, exceeding 172 millions of foot pounds per 1000 pounds of

[1] Presented before the Canadian Section meeting, March 3, 1926.

[2] Professor of Mechanical Engineering, University of Toronto, Canada.

dry saturated steam at 150 pounds and showed a mechanical efficiency as between steam indicator diagrams and suction and delivery water pressures of 96 per cent. None of the other types of pumps have given anything like such good results since.

The smaller steam-driven reciprocal units are often very wasteful, due to leaky plungers, leaky valves, tight glands on the rods, etc., so that careless operation may bring their efficiency down below 50 per cent.

CENTRIFUGAL PUMPS

The centrifugal or turbine pump has very largely displaced the plunger type in all large steam-driven sizes, and lends itself to high speeds of rotation, making it suitable for direct steam turbine connection. The efficiency of these pumps has shown a very rapid increase and the duty of steam-driven units has risen about 50 per cent in the last twenty years. They are relatively low in cost, occupy a small space, require little attendance and upkeep and have a long life.

The adoption of centrifugal pumps in America has almost entirely come within about twenty years. Like all new machines they made very slow headway at first, as they were difficult to take apart and repair, their properties were not well understood, many of the earlier machines had very low efficiency, they did not give the required discharge, and had a short life. Some of the early purchasers had good reason to regret their action.

The pumps had so many advantages that builders quickly put them into a practical shape and to-day they virtually control the water works pumping field. The earlier units rarely gave efficiencies exceeding 70 per cent, while large pumps have recently been made with 86 per cent efficiency. One of the important developments has been the adoption of the single-stage pump for a wide range of conditions, and there is a tendency to-day to increase the speed sufficiently to make single-stage pumps serve for high heads.

SINGLE-STAGE PUMPS

The adoption of a single stage simplifies the mechanical construction and reduces the cost, and gets away from many balancing problems. Builders very largely omit the guide ring, so much in use at one time around the outside of the impeller. This is also an advantage to the purchaser, as the ring always gives some trouble from leakage, and its angles are only suited to a single discharge

condition, although the range of discharges actually varies greatly in the same pump.

The use of the horizontally split casing has done much to popularize these pumps, as they may now be examined internally with great ease, and further, the use of impellers which give very flat power curves has proven a good asset. Pumps are now very largely made with this characteristic, the maximum power for driving corresponding to the discharge for best efficiency, and on each side of this point the power falls off.

HIGH-SPEED LOW-HEAD PUMP

At the present time there is room for further development of the high speed, low-head pump, only one or two makes of such machines being on the market now. The author recently ran a test on a pump for about 18-foot head, driven by a motor at 250 r.p.m., proportions causing the designer some difficulty, although fortunately the capacity of the pump was large. A very much more compact unit could have been made had it been possible to run at say six times the speed, and it is likely that further development of machines to suit these low heads will be made. One such pump, with a screw-type impeller, is in the Hydraulic Laboratory of the University of Toronto, and gives the required head of 12 feet and discharge of six million Imp. gallons daily, at 1500 r.p.m., with very good efficiency.

STEAM TURBINES

Reciprocating steam engines have been very little used for driving centrifugal pumps, except through belting, because of the relatively low engine speed and relatively high pump speed. A very common drive now is the steam turbine, which is direct-connected, but the steam consumption on small turbines is excessive and they are, therefore, rarely used for the smaller units.

The standby losses on steam-driven units is very high, the coal used for banked fires being often more than that used for pumping where some auxiliary plant is available, and for these and other reasons, not necessary to discuss, steam stations are decreasing in Ontario.

ELECTRIC MOTORS

Electric motors are now one of the most common sources of power for pumping in Ontario, and they serve splendidly for direct con-

nection. One fault with them is that they are frequently too small for their work, and run too hot. This is largely due to the fact that the pump either exceeds its capacity at given pressure, or that it is low in efficiency, or else is running at too high a speed. The purchaser is frequently so pleased, in the first case, to get more than he is paying for, that he does not realize the load being put on the motor. Low efficiency is usually a cause for rejection, but the author has come across so many cases where speed much exceeded that stipulated, that he feels attention should be given to this matter.

It is not unusual to find a pump purchased for a speed of 1750 r.p.m., running at 1800 r.p.m., due to electrical conditions and this results in an increase in demanded power of 9 per cent. If, in addition, the pump is high in capacity, it is clear that the motor will carry an undue overload. For these reasons, the motor should have an excess of 15 or 20 per cent of power over that expected for the pump.

Centrifugal pumps must be primed and are very sensitive to the presence of air in the suction, so if poorly set they may entirely lose their suction and run dry, causing considerable danger to seizure inside the pump, as it is ordinarily made. It is very desirable, therefore, to set the pumps as near as possible to the suction well, preferably so that they will be below the well level, and any gain that may be possible in the lowering of the pump is generally justifiable. A long suction pipe is also to be avoided.

STANDBY UNITS

For standby service, one of the most suitable pumping units is the direct connected centrifugal pump and internal combustion engine. So far gasoline has been largely used for fuel, since engines using it may be run at high speed, but heavier oils are also being used and adapted to such service, and are safer, cheaper in fuel costs and give no difficulty in operation. One unfortunate condition, all too common with such units, is that their setting sometimes causes them to be very noisy, and at times dangerous. Cases are not unknown where the hot exhaust pipe has set fire to the pump house.

Noisy operation can be avoided, and engineers would do well to realize that good work will not be done by the operator in a noisy pump house, and they should, therefore, deliberately plan to have a quiet unit.

Every pumping station should be equipped with a proper meter for the water as well as for the power supply. Such meters, now made by competitive companies, are remarkable in their accuracy, and enable the operator to keep a record of his output and efficiency, and every effort should be made to have this carefully done.

SPACE AND LIGHT REQUIRED

Most operators have ample time and facilities for keeping the stations and machines clean and free from rust and other objectionable matter. Polished surfaces should be kept bright and should not be painted, and the pump house should be designed with good light and plenty of space, and under such conditions the operator will usually take so much pleasure in his equipment that he will keep it in the best of condition.

DISCUSSION

W. L. McFaul: I have not found anything in Professor Angus' paper to which I can take exception. I am going to put in a standby pump for the Hamilton water works, but we have not as yet decided on the type of pump we will use.

R. H. Starr: I am going to stress this paper, and there are one or two things in relation to the pump house which we should stress. It is extremely important where a utility commission is operating the water works and electric utility, that the situation of the pumping house should receive considerable attention. Ten or twelve years ago we built a new pump house and put it in the residential section at one end of the town. Now they are worrying about the cost of changing the location of the station. With a little foresight we could have put the pumping station and the electric substation in one location near the centre of the town, not at one corner, and by doing that we could have avoided the expense of a long main and three operators.

There is one thing on which I do not quite agree with Professor Angus' paper, and that is in reference to having a motor with more capacity than the pump. I am doing this for the sake of you fellows who have to pay Hydro bills based on a 90 per cent power factor. If your motor is 200 h.p. and only called on to supply 175 h.p., then you are going to have a poorer power factor, and you will have to pay for it in your "thirteenth bill."

In connection with noise, we had a unit connected with a gasoline engine which unfortunately met with an accident due to the design of the engine. We now have a new unit which has a much steadier engine, although the same horse power. The exhaust pipe from the engine is carried about 60 feet in the waste-water pipe from our filter, and we get practically no noise from our exhaust. The only sign we have that the gasoline engine is running is the steam coming out where the waste water enters.

R. N. Austin: It is difficult to say that high efficiency is high speed. Nobody seems to have been able to design a pump that will give high efficiency at high speed at, say, 2000 r.p.m. You can run a pump at 1750 r.p.m. and attain an efficiency of 78 or 79 per cent. The problem is large capacity and low head. At high speed it is not possible to attain efficiency. The hydraulic conditions are not good enough in the pump to get high efficiency.

J. P. McRae: One point that I would like to stress is that 95 per cent of our pump troubles are on the suction delivery of the pump. I do not think engineers pay sufficient attention to intake conditions. The lower the suction, the better the performance you are going to get.

W. S. Lea: There is one point in connection with steam standby plants. Where the coal used for banking is large in comparison with the coal used for running, it is well worth while considering the installation of equipment to permit working the boilers at high rating, either by the unit system, powdered fuel or by mechanical stokers. A paper was read at the Pulp and Paper Convention at Montreal by one of the representatives of the powdered-fuel equipment manufacturers in which he said that there are plants now in operation that successfully employ the unit system without any drying equipment whatever. That is to say, it is quite capable of satisfactorily handling the coal with the moisture content it usually contains as received from the mines.

In connection with the problem that is sometimes met in motor-driven equipment, arising out of high starting current and comparatively low power factor, I would point out that there is now available, probably at an advanced cost over the better-known types of motors, a so-called asynchronous-synchronous motor, which

combines the starting characteristics of a wound rotor motor with the running characteristic of a synchronous motor.

While high-speed pumps are desirable, it must not be forgotten that they are open to the objection that they are not so well suited for high suction lifts as moderate speed units.

E. V. Buchanan: In view of the great reliability of electric motors, some stations could be made automatic. I have in mind doing that with one or two of ours at the present time. It is only a matter of having floats in the station, and it will run by itself for twenty-four hours at a time with simply a day operator to clean up the station and see that the bearings are properly oiled and the pumps in shape. I am quite sure that is feasible. I think that the use of an operator in an electrically driven station is a matter of the continuity of our own practice.

I would like to stress again the point in Professor Angus' paper about long and high suctions of centrifugal pumps. There are places where we have centrifugal pumps and where we have met with trouble due to long and high suctions.

The Chairman: There is no doubt but that this is getting to be the push-button age.

H. G. Hunter: I think Professor Angus is to be congratulated on his paper. He has put forward a question that can be well gone into by pump manufacturers. My opinion is that the efficiency of a low-head pump up to 20-foot total lift is probably somewhere in the vicinity of 60 to 65 per cent. I doubt very much if the average pump is efficient over that. It seems to me that a pump could be designed to operate at a little higher speed and get better efficiency. There is no question in regard to the setting of the centrifugal pump if conditions make it convenient to get the pump as near the water as you can. If it is possible I would back-plug a centrifugal pump. On the other hand I would not hesitate at all to put a centrifugal pump as a low-head pump in with a suction lift limit of 16 feet. I have a great number of them operating under these conditions and I have never had any difficulty.

N. M. R. Wilson: Speaking in regard to Professor Angus' remark about standby charges on boilers. We have to keep up steam with

our regular plants, and our records show in several cases where we have actually used the steam pump for the whole day at less cost than banking the fires. I have been in favor of the crude-oil engine for a good many years as a standby unit. The unfortunate thing is that the first cost of a crude-oil outfit is very high. If the installation charges could be cut down to a reasonable figure, there is no question but that the crude-oil engine would come into very general use as standby for driving a generator for electrical current.

James Bain: We have several places that are running automatically, but I think that it would be difficult to run our pumping station automatically. We have three different steam plants, and that means three gangs of men. Our plant has been in operation since 1859.

In building a plant I think you should centralize as much under one roof as possible. You must keep your steam plant away from your electrical apparatus. We have had a lot of electrical interruption caused through line trouble. Our line has broken down three times. I had to call in the assistant operators as firemen. These men had never handled a shovel before in their lives. We had to run on steam power for a whole week. We were the first to use Hydro. We made our start December 24, 1910. When you get up against a break-down it is hard to work your apparatus automatically.

Speaking about the power factor, there is a motor available now that cuts down the cost considerably, and where you have a pumping plant you can keep your power factor down if you put in a number of small units.

If you have a high-speed pump it is hard on the suction. The minute you get high speed in the pump you have lower suction. You cannot get high speed and good suction at the same time.

Wm. Gore: Speaking on the question of speeds of centrifugal pumps, they are really dependent upon three factors. First, the manufacturer has all the details and he can tell you what is best for the situation you have to meet. You have to take an article that has been developed by experience. Probably the manufacturer has spent a good deal of money in developing his pump.

The next factor is the power. The bills that we have to pay the Hydro-Electric Power Commission depend a good deal on the effi-

ciency of the pump we use. In fact I would say that an inefficient pump is dear as a gift. An efficient pump soon pays for itself in the saving in the cost of power. The Hydro Power Commission will come along and say, "You must have high-speed pumps." Why is that? They say if you have a low-speed pump the motor that drives it must have a large air gap, and they do not like that because the power factor of the motor is down. You must have a motor in which the rotor runs very close to the starter.

Then there is the question of finance. We all know that the higher the speed of the pump, the more the pump costs.

I believe in large pumps, the best efficiency seems to be obtained in the neighborhood of 50 pounds pressure. It seems as if two pumps in series is the solution. You must keep the speed of the pump up. We are forced into that by finance and by the Hydro Commission of Ontario.

With regard to the general question of pumping station design apart from the pumps: I think I laid my views on that point before this Association a year ago, and I can only reiterate the views I expressed at that time and say that I think a pumping station in order to get the best results should be worthy not only as to efficiency, but it should be something that a man in charge of it could almost worship. You should make it like a piece of artillery. A man will look after his guns because he loves them and because he can keep them clean and beautiful, and he will also keep them efficient.

I think that the pumping station should receive our most careful consideration. Last night I went to a moving picture show and I saw views of my old home district, and it gave me a sort of a homesick feeling. They were views of old London. Something struck me while looking at these pictures that had not struck me when I was there, and it was the absence in the streets of extraneous matter like poles and wires and all sorts of things all over the place. If you look through our streets you will see all kinds of that impedimenta that should not be there. I think we should apply the same efficiency to our pumping stations. They should be free from impedimenta. If there must be pumps, they should be under the ground and out of the way. I think the pumping station is the palace of our water works system, and it demands most careful consideration.

N. M. R. Wilson: There is one point that has not been mentioned regard to the push-button system, and that is the underwriters.

You cannot have your pumping house run automatically without getting your fire insurance rates up. The fire underwriters will insist on having the station manned by operators who will be always there.

E. V. Buchanan: I was referring to an electrically-driven station and I spoke of automatic control. If the pumps stop in such a station, the presence of an operator will not bring them on again. The station can be made to work automatically just the same as if the operator were there.

W. L. McFaul: We have an old pair of engines that were installed in 1859 and for sentimental reasons they are still kept in use as a break-down service. We were having a fire test on the market, and I do not know what put it into my head, but I put these engines on the first thing in the morning and I ran them through the test.

KEEPING THE WATER WORKS WORKING[1]

By C. R. Henderson[2]

I have been asked to write a non-technical paper which will in some way impress you with the importance of the service in which we are engaged and will also suggest some of the difficulties which have to be overcome in order that water service may be safe and uninterrupted.

While the business of water supply is important, it is not spectacular. No utility renders a more essential service and none has greater responsibility than the water utility. The people are dependent upon transportation, communication, light and power for their well-being and you often hear of the splendid contributions on the part of these utilities to comfort and public welfare.

The railroads transport food, raw material, finished products and passengers, but we are learning that there are many substitutes for railway transportation. If the telegraph or telephone lines go down and the mail service stops there are other ways of getting communication through. If the light goes out we can at least get the kerosene lamp out of the attic or borrow some candles. Likewise there are many substitutes for electric power.

Serious as interruptions suggested above may be, we doubt if any interrupted service is quite so serious as the interruption of water service in modern cities. There is no substitute for water and few substitutes for the service rendered by the water utility in urban communities.

Fortunately, no service is more reliable.

The distribution of water is not much affected by storms—earthquakes, perhaps—but wind and weather have little to do with cast iron pipe laid six feet under ground. Labor troubles and strikes do not reach us, our property is safe from fire (or ought to be) and we usually have a source of supply ample in quantity.

What then are the troubles of the water works man and what must he do to meet them?

[1] Presented before the Iowa Section meeting, December 2, 1925.

[2] General Manager, Davenport Water Co., Davenport, Iowa.

Perhaps the most serious difficulty is in maintaining the purity of the supply. Surface waters are becoming more and more polluted by sewage because of public indifference and official neglect. These waters, if used for water supply, must be carefully purified and closely watched for changes in character which sometimes occur suddenly and which require prompt treatment. Nearly all surface waters now require treatment, but so called "pure supplies" may be as dangerous as, or even more dangerous than, impure supplies if suddenly polluted when we may not be on guard.

Dangerously polluted water is usually followed by sickness and sometimes by death, and because other agencies are too slow to detect occasional impurities in the water supply, the operator of a water works must know day by day, and hour by hour, that his supply is safe.

History is full of cases in which uncounted losses have followed the sudden washing of sewage into a stream or lake, thereby causing an overload to the protection of a surface water supply, and there are many cases of the contamination of so called "safe waters" after they have been brought to the surface of the ground.

Our numerous duties sometimes conflict, one with another.

In the middle of the night a conflagration starts in the midst of valuable property. The water works is required to furnish, perhaps, five or ten times the quantity of water being pumped at the moment. It is not always easy, and it is sometimes impossible, to make all the delicate adjustments necessary to remove bacteria as efficiently in emergency as under normal operation, but the water man is supposed to do it.

The fire department puts out fires but a fireman cannot go far without a good supply of water to back him up, so we are advised to provide large mains to supply a number of hydrants simultaneously, in addition to other domestic demands, which may be heavy or light when the fire starts.

We are also advised to provide extra boilers and extra pumps and other expensive equipment for use in fire extinguishment.

Other supervisors set up standards of drinking water which require more and better devices for purification and much skilled supervision. In other words, the fire protection engineer is constantly improving the standard of fire protection and the requirements to be met by water works, and the public health man is constantly revising and raising the standard of quality. Both duties are important so it is

up to the operator to find a way to ride both horses at the same time.

The municipal engineer on the other hand is paving streets, installing conduits and other structures under the streets, thereby making it more and more expensive to install and maintain water works.

The sanitary engineer is increasing the spread of sanitary sewers and, in many cases, adding to the load of pollution that the water works man must extract from the water supply.

But we have yet to hear of the man who is striving to increase the revenue of the water works in order to make it possible to do the very much worth while things above referred to; this burden is placed on the water works man and he is suspected of selfishness as soon as he asks for more money.

Circumstances beyond our control have about doubled the cost of our service in the last ten years.

Many reports of public officials come to my desk in the course of a year and I am impressed by the number of warnings contained in these reports that apparently make no impression on the persons addressed. Reports of inadequacy, danger of interruption in supply, danger of damage to public health. I sometimes find the same complaint in several annual reports from the same city, so it is evident that no attention is paid to the warning, or, if so, nothing is effectively done.

As an example, the following is quoted from the report of an eastern city. "In a series of dry years our supply should, theoretically, furnish our present consumption. Unfortunately, however, our greatest reserves are in Westminster and the capacity of the present pipe line to the city is only about one half the daily consumption."

Why do we find these conditions so often? Probably because the public is indifferent or because of lack of funds. There should be no lack of funds to provide adequate and safe water supplies. The difference in costs between supplies inadequate and unsafe and those safe and adequate is not usually great, and nothing is more important than a safe water supply.

I think the water superintendent has more to complain about in the lack of public support of what he knows to be safe policies than he has in any other or more personal matters.

The water man has a fine opportunity to render steady service, day and night, to the people dependent upon him. He usually has a

pride in his job whether it be a big job or a little job. He knows too what Thomas R. Marshall said "He who serves the people would better serve with the understanding that the only reward he will ever get is his consciousness of having done his duty."

"Governments are ungrateful and speedily forget the sacrifices of their citizens," but for all that I believe "he profits most who serves best" and the consciousness of having done one's duty is a very considerable reward.

No profits are now probable in the water works business in connection with poor service.

Too many agencies of publicity are engaged in showing up the service rendered by the water man. Parties of experts come to probe into all the dark corners of what you might consider your private affairs and they publish to the world all your delinquencies and shortcomings and apply a scientific system of points of deficiency to what you have so proudly accomplished.

Again—if you have certain industries in your city the United States Department of Agriculture checks up your work in water purification. If a train or ferry boat taking water from your mains crosses a state line the United States Treasury Department has a standard for you to live up to. If you have a public hospital the hospital service checks you up and, also, the daily and weekly reports of your operations are welcome at the office of the State Board of Health. So it is "watch your step" if you would continue stepping Mr. Water Works Man.

However, if some manufacturer pours oil or discharges tons of organic matter into the river or if a municipality puts raw sewage into the water there are not so many agencies to caution them. In fact, I rather think they are within their rights because it is probable that your home town also contributes to the pollution—downstream of course—and not having "clean hands" cannot complain of its neighbors up stream.

In order that this paper may have a wider viewpoint, and, also, in order that it may reflect the experience of the water works men of this section, each member was asked to contribute some item of experience to illustrate what it means to keep the water works working. This paper would be too long if all the material received were included.

One superintendent writes that on a recent occasion an accident occurred at the pumping station requiring him to call in all the mechanics he could muster from the trades, to make repairs and to

work without stopping for forty hours before a temporary supply could be secured. He said that if a fire had occurred during the forty hours it would have been disastrous.

Another case reported involved a fire in a leading hotel, early in the morning when the temperature was 18 degrees below zero. Before enough water could be secured to control the fire the superintendent had to shut off the water mains supplying other parts of the town, thus concentrating all the water the wells, and the reservoir supply, would furnish, at the location of the fire. The result in this case was to create public sentiment for better equipment and so the bad conditions were remedied later on.

Another report covered a collision between a Ford and a fire hydrant. There was nothing strange about this for it occurs every day, but in this town the valves were covered with 6 inches of ice and were inaccessible for prompt use, so in order to stop the flow of water the pumps were shut down, the Ford removed and the hydrant plugged; but by this time the superintendent and his men were walking icebergs.

Within the past thirty days one of the principal mains in Davenport was found to have a crack in it. It was a 24-inch, Class C, cast iron pipe. As soon as the crack was discovered the main was shut off and the work of replacing the pipe begun. Service was maintained through other, parallel, mains but every water works man knows there was no delay in getting the principal main back into service. The men worked all day Friday and all day Saturday and part of Sunday, and if you attended a football game in Iowa on Saturday, November 7th you know the blizzard they had to work in. Every moment the superintendent and his men were doing all that could be done under such adverse circumstances. Did the public know what was being done for them? Of course not. No one knows but ourselves. No publicity would result unless we failed to do our job and the service was interrupted in consequence thereof.

In the city which is now our host, at 5 o'clock in the morning, a 20-inch plug blew out of a cross in the main feeder line between the pumping station and the reservoir. The pressure at the station dropped from 95 to 35 pounds. Within an hour the district for a distance of three blocks, which included the leak had been shut off and the pressure restored to normal. The public knew nothing of the accident until they read the account in the evening papers. The speed with which this shut off was accomplished was due to the acces-

sibility and good working order of the valves and the familiarity of the crew with their location.

Another close call in the same city occurred when the water department was making a new cross connection within three blocks of the Orphans Home. Fire broke out in the institution while the water mains were shut off and while several hundred children were in the buildings. There was, of course, no water in the hydrants to control the fire but by quick work and quick thinking several valves were manipulated and a double line of hose laid as a by-pass around the open main, connecting from a live hydrant to an empty one and supplying water to hydrants several blocks beyond to control the fire. The buildings were saved.

The following comment was received from one of the largest cities in our section.

> The water department operates as a unit of the fire department in case of second and third alarm fires or other serious emergency. Day or night, winter or summer, the superintendent and general foreman respond to these alarms under the same conditions as fire officers.
>
> Repair gangs and special equipment such as hydrant thawing steamers, oxyacetelene cutting apparatus, trucks and tools are ordered to the site of the emergency to handle not any trouble that might develop in connection with the water supply, but to assist in any other way that the senior officer of the fire department may request. On one occasion these men remained on duty at the scene of a serious fire, with the temperature below zero, for ninety-six hours with only such rest as could be obtained in nearby stores.

The dean of water works men, Wm. Molis of Muscatine, reports that:

> In the early days when Muscatine obtained its water supply from the Mississippi River the pumps began to act badly one afternoon. A sand bar had covered the intake 700 feet from the shore. Water from the elevated storage reservoir was discharged backwards through the intake to dislodge the sand, but without success, when fire broke out one block from the pumping station. Eight streams of water were required for the fire and service was maintained through the use of a suction pipe to the shore line kept open by men in the well. The next day a dredge was employed to remove the sand and the public knew nothing about it except that the water was a trifle muddy.

Another serious incident occurred in the same pump well when a man who was sent down to do some work reported a dead body in the well. After telling the man *not to say a word* Mr. Molis says

> I got on rubber boots and old clothes to investigate the trouble. Going down in the well I found two large cat fish weighing about 200 pounds. I called to the

men to get the derrick ready with ropes and tackle to hoist the body. When I myself came up I was surprised to see the Coronor, the Sheriff and police, besides 1000 people, waiting to see what was supposed to be a dead body.

Hannibal, a charter member of this Association, reports

A few days ago we noticed an unsatisfactory condition in the filter effluent which could not be readily explained. The settled water turbidity was fairly low, about 100 p.p.m., coagulation was excellent, the filter beds seemed to be in fine shape, yet it was almost impossible to obtain a clear effluent. As the days went by our condition became more aggravated. The filter runs grew decidedly short in spite of frequent washings and increased dose of alum, and the effluent became more turbid.

The color of the water was normal for the Mississippi river at this location and microscopic organisms, chiefly Melosira, were not excessive. As a last resort we riged up a chlorinator and applied chlorine gas at the point of application of our coagulant, to the extent of 6 pounds per million gallons, when our trouble vanished like a cloud.

The following interesting reply was received from one of my neighbors, W. J. Schneider, General Manager, Bettendorf Water Company:

As you know we are also connected with the Bettendorf Light and Power Company. Comparing the two services—water and electricity—so far as grief of the service is concerned, it is a whole lot easier to deal with the public on the subject of electricity than it is on the subject of water. The average man will kick on a $1.00 monthly water bill but he will never say a word on a $2.00 light bill. Electricity is easy to buy, easy to meter, and easy to deliver. Water you have to manufacture yourself, it is hard to meter accurately and is expensive to deliver. Our water investment is six times our electric investment but our gross receipts on water are only one-half of the electric gross receipts. In our water plant on our present scale of rates we turn our capital once in fifteen years. In our electric company we turn our capital every three years. . . . . A peculiar condition exists in that we have never found a single person who wilfully stole water from us. Stealing electricity is quite a common occurrence."

Perhaps the greatest handicap a private water company has to overcome is the quite general belief held by the public that the sole and only object of the company is the making of money.

Of course, the company hopes to make some money. Any sort of good service would be difficult, if the business were running at a loss. But did you ever stop to think that it is perfectly proper for a utility to make a reasonable profit? It is not even bad morals. Of course, you don't want them to take it all—but there's no danger. Very

few water companies take in as gross revenue more than 12 per cent or 14 per cent of the actual value of their property and most of them have a gross revenue of not more than 10 per cent. Operating expenses, maintenance expense and taxes have to be taken out of that before there is anything for bond interest, dividends, depreciation or surplus.

I know of more than one water company that pays one-sixth of its gross income for taxes alone.

It may surprise you to know that almost no other large business could survive on the meager earnings of a water company. It may be that water companies may not continue to be an exception, but it has been done because of the safety of the investment and its absolute necessity as a service for which there is no substitute.

If I were to ask a boon of the public it would be that it treat its public utilities as a good employer treats his private servants and employees. Dealing out censure when careless or indifferent service is rendered, penalties, perhaps, for serious lapses, but commendation, encouragement and reward for good service. I believe that recognition of a sincere and intelligent effort to serve would result in much more of this kind of service.

FINANCIAL REPORTS OF WATER WORKS OPERATION[1]

By H. F. Blomquist[2]

The success or failure of a service utility is measured in two dimensions: the quality of service it furnishes, and the cost of the service given, whether it is low, moderate, or excessive. A public water works furnishes three distinct kinds of services at a certain cost to those who receive them. This paper will deal with the cost side of water works operation, and will treat the subject from the viewpoint of municipal operations.

Students of government have recently stressed more and more the importance of the budget system in expenditures of public money, and have recommended this method as especially important in municipal affairs. The principle of the budget system is to determine before hand the amount of money to be expended for a particular activity of the government, raise the amount for that particular purpose, and use it for no other. We must concede that this is the most business-like way of conducting public business.

When a municipality undertakes the operation of a water works it enters a field of service that can also be furnished, and in many instances is furnished by a private corporation under its own management, subject only to certain governmental regulations, necessary on account of the monopolistic nature of the business and its uses of public streets and other privileges in a community. Public ownership of water works has become popular because water service is so closely connected with the public welfare, especially in its relationship to fire protection, street cleaning, sewer operation and other public uses.

In harmony with the principle that each activity of a municipality should be maintained by money set aside for that particular purpose, the finances of a municipally owned water works should be kept entirely separate from other funds and be used only for the promotion and operation thereof. This is further emphasized by the

[1] Presented before the Iowa Section meeting, December 3, 1925.

[2] Superintendent, Water Works, Cedar Rapids, Iowa.

fact that the water works is performing a function that can also be performed by a private party, which would have to provide its capital and receive remuneration for all services given. Since the sole function of a water works is to furnish certain tangible services, the total cost of operating and maintaining it should be derived from those who receive them, and each of them should bear his proportional share of the cost. In other words, a municipal water works should be operated as an independent department and be self-sustaining no matter how its capital investments were first provided. If they were provided by taxation, the water department should be debited by the municipality to the full amount and subsequent interest charges until the same is repaid or balanced by credits for public services given to the municipality, and should be credited with all public services such as water used for street and sewer flushing, parks, fountains, and for its share in fire protection. The water work's books should show its full indebtedness, and carry that indebtedness until paid from its own earnings or credits.

All business enterprises must maintain a system of accounting best suited to their own needs, one of the purposes of which is to reveal at any time its financial condition. In order to make a correct statement of the financial condition of a water works, its system of accounting must take into consideration all items that belong to its invested capital, interest and all outstanding obligations, a sinking fund or other method of amortizing its obligations in amounts at least as large as its depreciation and loss of value on account of obsolescence or other causes. It should also account for the actual value of all services given, whether paid for in a direct way or not. Only when all these items are properly accounted for can a correct statement be made of the financial condition.

In addition to the financial accounting, and of equal importance, is a proper system of operating records. Record keeping in detail of the various operations of the plant are important not only for the historical information, but also for studying the performances of its various units. A certain machine, for instance, may be far from worn out, but, if its efficiency is so low that the difference in cost of operating it and one of a newer type with higher efficiency, is more than the interest on the cost of a new machine, it is economy to scrap the old one, even though it could continue for a long time to do the required work. The public, as owners of a water plant, often know very little about the condition of their industry, whether its

operation is successful from a financial standpoint or not. Their only means of finding out is from the quarterly or annual reports issued. These reports should, therefore, be so arranged that they will present in concise form the results of the plant's operation for the period covered, including all proper overhead and depreciation charges and all proper credits, and also give a general statement of the financial history of the plant. In addition, summaries of operating data for previous years are valuable for comparison as well as from a purely historical standpoint.

This paper is not intended to present any definite system of accounting, but to call attention to some sound principles very often omitted in reports of municipally owned plant. Many plants have been purchased or built with proceeds from bond issues or other indebtedness assumed by the municipality and later partly amortized by general taxation, mainly because fire protection was the first object sought. Later, as the water services were extended, it was often a mere matter of getting funds in one way or another to balance the expenditures, and still later, when earnings have exceeded the expenditures, the surplus money has been transferred to some other fund of the city. In such instances, a true cost accounting has not been made of the operation of the utility. Such methods do not promote efficiency and do not show its owners the actual cost of the services they receive. The services from any undertaking must be worth the cost; otherwise, the undertaking is a failure and should not be attempted.

Public water services are generally cheaper than any other commodity when their full values are considered, and are well worth their costs. If the plant and its accounts are given fair treatment, the results will be fully justified.

THE MENACE OF CROSS-CONNECTIONS IN A PUBLIC WATER SUPPLY[1]

By R. F. Goudey[2]

A cross-connection is a physical arrangement between a public water supply and a secondary water system, usually privately owned, whereby a flow of water into the public water system is possible. Such secondary supplies are scattered over the state by the hundreds and are to be found at most industries using moderate volumes of water or at buildings requiring the best of fire protection.

The private companies install cross-connections for their own convenience and for economical interests with little or no consideration for any necessary or reasonable precautions for the protection of public health. The seriousness and extent of this problem is little realized and the evidence, though considered most favorably from the private company's standpoint, nevertheless points to the inevitable conclusion that cross-connections between private and public supplies should no longer be tolerated.

Dual supplies have a legitimate use, but only when they are safely separated. Private interests forward many reasons for interconnecting supplies among which are:

1. Insurance rates for buildings or industries can be cut one-third to one-half if a duplicate water supply is provided, incidentally safeguarding life and property and insuring continuance of employment. The connected supplies in this case are usually separated by check valves or gate valves where other means of separation are not provided.

2. Large sums of money can be saved by industries substituting a cheaper and inferior water for the public supply for their processes which can be adapted to such water, while reliance for domestic, boiler and emergency use is placed upon the public water supply. Often in this case the two supplies are separated by a main check valve and a number of gate valve connections between the two systems at other points.

[1] Presented before the California Section meeting, October 6, 1924.

[2] Resident Engineer, State Board of Health, Los Angeles, Calif.

3. Some industries require a softer water, or water better adapted in other ways to their industrial processes than can be provided for by the public system. Connection with the public supply in this case is made for emergency use and is controlled by gate valves.

4. Great economy in swimming pools can be effected by equipping them for recirculation and purification, relying on the public supply for water for drinking purposes, showers, washing of filters, and periodic filling of the pool. Often only valves between the two systems are provided.

5. Some industries, when operating below normal, find it more convenient to temporarily turn on the public supply instead of starting up their private pumps. In this case nothing other than gate valves separates the two supplies.

6. It is advantageous to fill the salt water fire systems with fresh water after each fire to prevent excessive corrosion. This is occasioned by bypassing water around the check valve with a gate valve connection.

7. In many cases private pumps can more easily be primed from city water pressure by merely opening a valve.

The argument is not to negate any of these advantages, but to insist that they be gained at no sacrifice to public health. One would think this a fact too elementary to be mentioned, but it is one that has been ignored by waterworks officials, engineers for private companies and health officers. Instead of spending the necessary sums to separate properly the two systems the private companies usually install the easiest, cheapest and most direct means of connecting them. Herein lies the principal danger.

Any intent to correct the present practice in this matter, to say nothing of eliminating existing incorrect installations, will be met with strong opposition from private companies, insurance agencies and passive resistance from most waterworks officials. The California State Board of Health has passed drastic resolutions regarding cross-connections, but it will take a strong educational campaign and a determined stand on the part of health officials to eliminate the existing menace. One author states that, if the public knew of the dangers they are exposed to, they would rise up in arms against further use of cross-connections. It is well, therefore, to clearly state the factors indicating the seriousness of the menace of cross-connections in a public water system.

MENACE FACTORS

With the increased cost of water from public systems contrasted with the growing competition of private companies necessitating their development of cheaper sources of supply, and with the phenomenal success of automatic fire sprinkling systems, the number of new cross-connections is increasing faster than the normal development of new industries.

Cross-connections are never made twice alike—some are in conjunction with equalizing tanks, others are connected direct to the private distributing system, often they are buried in the boiler room or are scattered through the yards or buildings. Combinations of check valves, gate valves, and intermingling of the two systems are steadily becoming more complicated and intricate, as new uses for making such cross-connections continue to develop.

The controlling factor is pressure, which, during critical periods, if not at all times, is higher on the side of the private water system. False reliance is often placed on private systems supposedly having less pressure than the city supply, for, during periods of maximum use in a public supply or during its repair, the pressure on the private system invariably exceeds that of the public system. Many industrial plants install fire pumps in their private water systems to increase pressure during fires. Such pumps are "tested out" several hours a week, during which periods the pressure always exceeds that of the public water system. In some installations fire pumps discharge directly into the private distribution system without any equalizing tank, in which case the pressure may be built up much higher than the public water system. Generally speaking, in all cross-connections the pressures on both private and public systems vary hourly, sometimes being greater on one, sometimes on the other. Water will flow in enormous volumes through the slightest opening into the public supply, if the direction of the differential pressure is toward the public system.

The secondary source of supply is invariably polluted. From the very nature of its development it has to be a cheap supply and from the nearest body of water available, whether it be ocean, harbor, lake, pond, lagoon, slough or well. Obviously no consideration can be given to location of sewer outlets, bacterial quality, protection against pollution, mineralization or appearance. Most of the private companies warn their employees not to use the private system for

domestic purposes, for the courts hold that where pollution of the secondary supply is common knowledge the private company can not be held accountable for damages. In some cases the private water supply is safe, but from aesthetic standpoints it is still objectionable from its saltiness, turbidity, difference in temperature, or mineral content, to permit it to gain entrance into the public distribution system.

Since the secondary supplies are usually polluted and difference in pressure at critical times tends to cause a flow of water into the public system, actual pollution results almost inevitably, since all devices attempting to separate two supplies directly connected are positively unreliable. Such devices as have been installed include single or double check valves, gate valves, or a combination of gate valves and check valves.

A check valve is an enlargement in the pipe line where a clapper is hung on the inside near the top and which opens or closes on an opening in the main line as the pressure from either side acts upon it. The earliest of such valves were constructed entirely of cast iron, with the inside rough and cramped, easily permitting the clapper to catch on the burrs on the side or top or be jammed. This type of valve was universally condemned. The modern check valve is an outgrowth of the former cast iron valve in which all the moving parts are made of bronze with supposedly ample clearances and a clapper faced with hard rubber seating on a bronze disc of ample width to prevent injury to the rubber. Check valves leak on the slightest provocation, a fact well known by waterworks officials. Leakage in some instances has been recorded up to 200 gallons per minute. In one case a check valve passed a sufficient volume of water to throw a fire stream across the street. A city engineer in Massachusetts on examining some check valves found one fixed at 45 degrees with evidence of not having moved for several years. Meter readers in several instances have recorded backward reading of meters, indicating a seepage back through check valves. To think that mechanical perfections will prevent leaking of check valves in the public and private water systems as they exist today is absurd and illogical. As long as either supply contains substances which will lodge or accumulate under the clapper, such as pieces of sticks, sand, gravel, mud, clumps of moss, or fish, the proper action of all types of check valves will be interfered with.

The National Board of Fire Underwriters, realizing the complete-

ness of the evidence against single check valves, made recommendations sixteen years ago for installations calling for two check valves with means for testing tightness of both valves periodically. In a report of one of the inspectors of the National Board of Fire Underwriters sixty-one installations were found leaking in one valve and six in both check valves. One water superintendent in the east, after sixteen years experience with twelve sets of duplicate check valves inspected weekly, writes that they "need eternal vigilance, do leak on the slightest provocation, both are found leaking at the same time, and there is no assurance of tightness after test." The insurance companies have now gone a step farther by recommending installation of alarm devices to give warning when leaks occur. Undoubtedly such devices are a great improvement over the original check valves, but of what avail is this mechanical perfection since it does not hit at the real difficulties in the problem?

Enclosed devices in general are never reliable. If one valve can leak, so can two in succession; and if not conscientiously watched, are twice as bad as one valve. Double check valves are at best poor contrivances and tend to give a greater feeling of safety than is warranted by the facts. Until the personal element, insuring positive operation of such valves is cared for and until the water in both systems is filtered by conservatively designed treatment works, polluted supplies under no circumstances should be connected to a public supply through check valves.

In other cases the two supplies are separated by gate valves, some being adjusted daily either to prime pumps or for temporary use of water and others being more or less permanently closed or forgotten. In the first instance danger comes from failure to close valves tightly each time or to close them before water from the private system can gain entrance into the public system, if the pressure from the private side is suddenly increased. In the second case the valves may be so aged that they commence to leak. In either case the valves may be tampered with by ignorant or over-zealous employees. Valves have been put under lock and key, but this has not eliminated the danger from the personal element. It is evident that cross-connections, through gate valves are more pernicious than through check valves.

The greatest dangers, after all, are: first, the lack of appreciation among waterworks men and engineers of private companies of the extent and seriousness of this menace; second, the failure of health officers to understand problems involving engineering and mechanics;

and, third, lack of supervision from outside agencies to ferret out such connections.

EPIDEMICS RESULTING FROM CROSS-CONNECTIONS

That this discussion is not academic or theortical is borne out by many serious typhoid epidemics which have been traced directly to cross-connections as just discussed. The most notorious epidemic occurred in 1903 at Lowell, Massachusetts. Owing to failure of one or more check valves to hold during a period when fire pumps operated on a fire protection system owned by the Locks and Canal Company sufficient polluted water was pumped into the public distribution system to cause 196 authentic cases of typhoid fever and 16 deaths. Another important epidemic occurred in Van Wert, Ohio, in 1913. Here a polluted private supply in the Cincinnati-Northern railroad shops gained access to the public water system, the pressure of which suddenly dropped, causing 600 cases of sickness, 25 cases of typhoid fever and 2 deaths. A rather extensive investigation was made in Philadelphia in 1913, during which time 72 per cent of the cases of typhoid fever at Philadelphia were estimated as having originated from a series of faulty cross-connections in the industrial district. In Circleville, Ohio, in 1914 polluted water from the private supply of a strawboard factory leaked through two gate valves and two check valves and polluted the public water system, causing 43 cases of typhoid fever and 2 deaths. Elgin, Illinois, in 1916 had a rather large epidemic, in a watch factory resulting in 18 deaths. In Franklin, New Jersey, in 1922 leakage from a private water system at the New Jersey Zinc Mines leaked past a 3-inch check valve causing an epidemic of 140 cases of illness, resulting in some typhoid. The most recent epidemic occurred at Everett, Washington, in July, 1923. A polluted water supply from the Eclipse Mill gained entrance to the public distribution system through an open 6-inch gate valve ignorantly installed by water-works officials and which became dangerous when the city pressure dropped below normal, causing 2000 cases of diarrhea, 77 cases of typhoid fever and 11 deaths. Serious authentic epidemics have occurred at Akron and Springfield, Ohio; Toronto, Ontario; Rockaway, New Jersey; Bloomington, Illinois; Milwaukee, Wisconsin; St. Paul, Minnesota; Mannington, Nitro and Piedmont, West Virginia; Watervliet, Ithaca, Newburg, Herkimer and Saugerties, New York; and Hoosac Falls, Massachusetts. The number of minor and un-

recorded epidemics occurring in the ten states above mentioned, to say nothing of the remaining states where publicity is never given to these matters would without doubt, if discovered, show even a greater extent of this menace than is recognized.

Records show that there have been at least 2000 authentic cases of typhoid fever directly traceable to faulty cross-connections and over 100 deaths. This represents an actual cost of over three-and-a-half million dollars with the actual loss of many times this amount. The menace from cross-connections is expressed in terms of million of dollars.

Many cases are on record where the public system has been supplanted by water from a private water system, greatly impairing its use for domestic purposes, but fortunately resulting in no disease.

At Rochester, New York, a gate valve at a lift bridge operated by two supplies was opened by an ignorant employee and a large portion of the distribution system was filled with objectionable water before its discovery. In New Bedford, Massachusetts, in 1903 a woolen mill pumped so much salt water into the distribution system through a check valve that it put the fire steam boilers out of operation. At the California Cotton Mills at Oakland, California, in 1917 a large volume of salt water was pumped into the distribution system through a 6-inch leaking check valve, affecting a large area in Alameda and Oakland. At Pinole, California, a dangerous and dirty, but chlorinated, water was pumped into the distribution system, but was discovered before any serious consequences resulted. At San Pedro, California, several instances have occurred where canneries pumped salt water back through gate valves accidentally left open, until citizens complained of saltiness in the drinking water. Only last month an epidemic of twelve cases of typhoid occurred in the Southern Pacific yards, Sacramento, from use of a polluted, but supposedly treated, secondary supply. A cross-connection existed with the municipal water system, but the epidemic was confined to the yards.

The menaces from cross-connections in public water supplies are briefly:

1. The number and character of new cross-connections is on the increase.

2. Secondary supplies, since they are developed principally for economical considerations, are often dangerously polluted.

3. The pressure on the private systems at times, if not continually, is higher than the pressure on the public supply.

4. Check valves or gate valves separating the two supplies are unsafe and unreliable means of separating the supplies, since analyses of the underlying factors clearly indicate that in spite of mechanical perfections these mechanisms fail to function properly, not only because either supply contains substances interfering with positive action of check valves, but also because of the lack of human control to continually watch such installations, as well as to prevent tampering with or manipulation by ignorant employees. This finding also applies to the type of installation designed by the Associated Factory Mutual Fire Insurance Companies, approved by them and recommended by the National Board of Fire Underwriters.

5. Numerous epidemics have actually been caused through faulty cross-connections, causing losses totalling millions of dollars.

6. Waterworks officials, private engineers and health officers, except in places hit by the epidemics above mentioned, are unaware of the magnitude of this menace which, in addition to lack of supervision and education to ferret out all cross-connections, constitutes even a greater menace which cannot be overestimated.

The remedy is to discontinue all cross-connections with polluted supplies and rightly all cross-connections regardless of quality of water. By slight cost to existing installations and proper consideration for new ones, all the benefits from use of dual supplies will be secured and the two kept separate, if the city supply feeds separate systems throughout or is made to discharge overhead into pumps, tanks or towers, either for gravity or pump supply to the private system. Tank supplies in some cities are just as acceptable to the insurance companies as a direct connection. However, where the pressure on the public supply is unreliable or uncertain, booster pumps can be installed for emergency use to raise the city water to elevated tanks, in which case the fire protection would be increased.

The recommendations are the usual conclusions made by health officials of cities and states which have suffered heavily from epidemics due to this cause. The cities of Lowell and Philadelphia and the states of Washington and Minnesota are the only localities requiring complete separation of the two supplies. Ohio, except for temporary tolerance of some cross-connections of the double check valve type, also insists on complete separation. Pennsylvania and

California require separation except where both supplies are under state permits.

So far as is known, no other state has any regulations regarding cross-connections, the chief reason undoubtedly being a genuine lack of appreciation of the importance of this subject.

Health officers should coöperate with waterworks officials, find out where cross-connections exist, require separation and in the case of opposition refer the matter to the state by citing the private company to make application for their water supply, as required by resolution of the California State Board of Health, dated November, 1919, and amended May 12, 1924.

THE INVISIBLE BALANCE SHEET[1]

By Warren R. Voorhis[2]

A prosperous utility is proud of its balance sheet. It is printed on folders and stamped on blotters; it waves from the masthead. It is necessary for a utility to have a balance sheet, but this admission leaves us free to say that a balance sheet is a form of literature distinguished by a conspicuous lack of charm.

It is an invention of accountants, an unimaginative tribe, and is an attempt to picture a business by arithmetic, a medium which is deficient in flexibility. Figures may be made to tell the truth; they cannot be made to tell the whole truth.

It may be truthfully said of one of Sargent's pictures that it is 4 feet high and 5 feet wide, and contains 20 square feet of canvas; but these statistics do not fully develop the idea of the picture.

I do not say that a certain amount of information about a utility cannot be gathered from a balance sheet by those who are trained to that somewhat dismal trade, but I do assert that some very valuable assets and some serious liabilities are never shown there.

GROUNDS AND BUILDINGS

I like to study the items of the balance sheet of a public utility with which I am acquainted; for example: "Station Grounds and Buildings, $290,000." This is an attempt by arithmetic to describe these buildings and structures.

But I see a sweep of broad river, curving about a level place set about with trees, with a high green hill rising behind it. The buildings are of gray slate, warm red brick, and white stone; the waters in the reservoir are shining in the sun. The driveways are

[1] Reprinted from the Electrical World, Vol. 87, No. 15, April 10, 1926, page 756.

Not often is it so freshly emphasized, as in this article, that "beauty" of spirit and of matter, is not in conflict with "use."—*Editor*.

[2] Vice-President of American Water Works & Electric Company, New York, N. Y.

marked with whitewashed stones, which is old fashioned, but green grass and whitewash are the cleanest combination in the world. The entrance gates are open and people sit about under the trees, and children run about in the grass with never a $5 fine sign to stumble over.

The chief engineer, tilted back in his chair by the door of the boiler house, watches the sun drop into the river. And the dog of the firemen mitigates the austerity of his guardianship with a benevolent toleration for the rights of humanity. This pump station does more than pump water—it is a place of peace and quiet beauty. And the town is proud of it, as every town ought to be able to be proud of the buildings and grounds of its public utilities.

You cannot see the open gates, and the whitewashed stones, and the green grass in the balance sheet, because beauty eludes words, as well as arithmetic. But as long as people continue to love such things, they should be listed in the "invisible balance sheet" as valuable assets.

One time I visited a utility property and was shown the balance sheet. One entry read: "Office Furniture and Fixtures, $6000." My respect for the meticulous accuracy of accountants does not permit me to make actual changes in a balance sheet, but mentally I multiplied the $6000 by three and transferred the whole item from the asset to the liability side.

Those fixtures and that furniture produced in that office an atmosphere of settled, permanent melancholy and solid gloom which remains in my memory to this day. The walls were painted a deep, durable green; the places from which calendars and pictures of candidates had been removed were lighter in color. The eye rested with relief upon a white place in the ceiling where the plaster had fallen away.

The centerpiece of the office was the office stove. It stood on its four legs on a piece of zinc with an iron pan underneath for ashes and a rusted nickelplated urn on top for ornament. The color of this stove was red at the bottom, fading to gray at the top.

The stovepipe wavered upward for 6 or 8 feet and then definitely angled away about 20 feet to a hole in the wall. This pipe was supported by rusty wires from the ceiling, and the wall around the hole where the pipe escaped was black with soot.

The space for the public was divided by a partition from the space for the inmates. There were two holes in this partition; over one it

said, "Complaint Department;" over the other it said, "Pay Here." The linoleum in front of the complaint window was worn down to the bare boards. As a rule I am opposed to a "Complaint Department" in a utility office, but it did harmonize with this office.

In the public part there was never a bench or a chair where a woman could put her package or her baby while she fumbled for the bill she must produce at the "Pay Here" window. The wall desk for public use was so cleverly placed to avoid all light that it could not have been accidental. This was probably pure malice. Finally, the lower half of the front window was painted a dead black.

A man in that town told me that once he went to this office to pay his bill and that he took his dog. And that man said that all the time he was there this dog sat down and howled and would not be comforted until he was once more out in the sunshine. I do not think that the man intended me to take this story literally, but he did mean to tell me how that office affected him, and just made up the part about the dog.

Now in the "invisible balance sheet" where should this furniture and these fixtures be placed? As long as people get impressions from material things, as long as they are affected by their surroundings, such an office is a heavy, self-inflicted liability, regardless of accountants and arithmetic.

CHIEF ENGINEER'S SALARY

I have been looking at the income account of a utility that I know very well. An "income account" is another contrivance of accountants, with the same limitation as the balance sheet. There is an item: "Chief Engineer's Salary, $4200." This is the best the accountants can do for John Evans.

The service record in our office shows that John Evans began work at the station where he is now chief engineer, April 20, 1886. Forty years. A working lifetime spent in one place, doing one thing.

When I go to this plant Evans always says to me, "In 40 years the town has never been out of water, even for one hour." Every time I go he says this to me. I suppose because he is old now and he forgets that he has told me before. But I think it expressed the dominant note in his life. It expresses his lifelong conscientious fidelity to a responsibility, although John Evans would not dream of putting his day's work in this stilted language and, besides, his repeated expression is much more simple and strong than mine.

Evans has witnessed ten changes of city government in his time, and for many years the young fire chiefs, driving red automobiles against traffic rules, have come out to the station to talk things over with Evans. New plant managers come, stay their apppointed time and depart upon their lawful occasions, and Evans patiently undertakes the education of a new manager, who, if he is a wise young man, will give nearly as much heed to Evans as to the advice from the experts of the home office.

As the years pass the whole organization has become proud of John Evans, proud of his long service, his experience and knowledge of the property, and now, after 40 years, that town is proud of John Evans. He has become a public institution, like the Soldiers' Monument. And the Mayor, who has a fine turn for oratory, says that such a record reflects credit upon Evans and his company and that such loyalty and fidelity and such respect and confidence is the kind of relationship that ought to prevail in all industrial life.

And all the time Evans, a bent man with grayish hair, and the pipe he brought with him to the job, goes about his day's work at the station, one day being much like another. And he says, if you interrupt him, "In 40 years the town has never been out of water, even for an hour."

THE MORAL OF EVANS

I conclude, from thinking of John Evans, that in the making of a man the size of the stage does not matter. Evans lives in a house near the station. He brought his wife there, and from there his children have gone out to lives of usefulness. He has spent all his years at his home or at the station, by the margin of a quiet river just outside a small city. I do not know whether his has been a life of distinction or not, but if loyalty and fidelity and honesty and conscientious discharge of duty enter into the making of success, then by such a standard John Evans has succeeded beyond most of the men of my acquaintance.

I further conclude from the life of Evans that a public utility which has an organization of men and women with something of his conception of duty possesses an asset which belongs in the "invisible balance sheet." Buildings and wires and meters and things terrestrial which can be handled and seen do not of themselves make a utility; the spirit of the business must be found elsewhere. The utility which maintains a relationship with its men and women which

inspires them and puts the spirit of service into the business has an asset which defies arithmetic, because there is no way of measuring its value except by its loss.

ASSETS AND LIABILITIES

This is the end of the moralizing part of my article. The "invisible balance sheet"—in my opinion all directors of public relations should be certified public accountants, relieved, however, from the limitations of figures and qualified to deal with those values which elude the property balance sheet. I would require such directors to keep a balance sheet, constantly revised, and with an understanding that no item in the liability side has there a permanent abiding place; it is to be lifted to the asset side at the first opportunity.

Especially I would not require the "invisible balance sheet" to balance exactly, assets against liabilities, which is the chief obsession of accountants who make the property balance sheet. In the "invisible balance sheet," when there is a balance something is wrong. And finally I would not expect a utility to build up the asset side of its "invisible balance sheet" by large money expenditures, for we were long ago told that the things of the spirit cannot be bought with money.

But good judgment, common sense, tact and unfailing and sincere courtesy, thoughtful consideration for the people we serve and for the men and women who help us serve, these are the expenditures, this the legal tender which effects changes in the "invisible balance sheet."

A public utility with its treasury empty of such currency may with confidence expect to find its regular balance sheet and income account adversely affected, so closely do things invisible impinge upon things material.

PLUMBING AND SERVICE COMPLAINTS[1]

By V. E. Perry[2]

Up to about 1890 the Spring Valley Water Company used as a standard for house services a $\frac{1}{2}$-inch driven tap with a $\frac{1}{2}$-inch lead service pipe, and from 1890 to 1908 used $\frac{5}{8}$-inch driven taps and $\frac{5}{8}$-inch lead services. In 1908 we adopted as a standard for residential and small commercial services a $\frac{3}{4}$-inch screw tap with a $\frac{3}{4}$-inch galvanized pipe service.

These changes were brought about by an increasing per capita water consumption due to a change in the plumbing conditions, as shown by the following record of population and water consumption:

Period	Population (U. S. Census)	Consumption	
		Total.	Per capita
		gallons	*gallons*
1880	234,000	12,648,000	54
1890	300,000	20,416,000	68
1900	343,000	25,644,000	74.2
1910	416,900	35,604,800	85.4
1920	508,400	36,167,700	71.1

In 1918 the entire city was metered, which accounts for the decrease in water consumption as shown in the above table. There being a decrease of 16.7 per cent or about $\frac{1}{6}$ in the per capita consumption for the decade 1910 to 1920, due to metering.

The first patent toilet was a "pan" water closet, which had an inverted conical bowl with a pan at the bottom and was operated by a pull up handle in the toilet seat. The pulling of the handle dropped the pan and also operated an automatic valve not unlike (in its operation) the present flush valve. This threw a small stream around the sides of the bowl. The dropping of the handle raised the pan and

[1] Presented before the California Section meeting, October 16, 1925.

[2] Assistant Manager of Water Sales, Spring Valley Water Company, San Francisco, Calif.

allowed the valve to close. These toilets together with a wooden or zinc lined sink, a small marble wash stand and an occasional zinc lined bath tub, were amply supplied through a ½-inch service and a ½-inch house pipe. Later for sanitary reasons the Golden Gate Toilet was adopted. These toilet bowls held from two to three gallons and together with the increasing use of bath tubs and the discontinuance of the roof tank, because of the adoption of the galvanized range boiler in place of the copper one, made it necessary to increase the size of the service and the house piping.

Still later the introduction of the high tank, then the low tank in toilets, together with shower baths and instantaneous heaters, required another increase in the standard size of the service and also in the house piping.

I might hazard a forecast that the time is not far distant when we shall again have to increase our standard services in order to provide for the more modern plumbing such as flush valve toilets, and side spray showers, etc., which are now generally used and which require oversize services and house pipes.

These changes in the plumbing conditions have brought about a number of complaints of "poor pressure," by consumers who, having installed too small a house pipe, could not get sufficient water for the proper operation of such fixtures as shower baths, instantaneous heaters, etc., and asked the water company to investigate the situation.

In all cases where the size of the service was less than the present standard ¾-inch we have increased it, with the understanding that, if this did not remedy the condition complained of, the consumer would increase his house piping. The wisdom of this policy of increasing services in advance of the house piping is apparent for it changes the responsibility of good service from the company to the consumer.

Our dealings with the plumbing fraternity in general have always been pleasant, but occasionally one of the smaller members of the craft will cause the water company considerable annoyance by his lack of knowledge of some of the common factors in hydraulics, such as frictional loss being called "poor pressure," and instructing his client that it is "up to the water company to increase the pressure," usually a physical impossibility. When the water company is called upon to remedy these conditions our investigation invariably develops that the cause is due to the small size of the house pipe or the service pipe or both.

There were 65 cases reported on during May, June and July of 1925. Of these there were 48 cases where the services were the same size or smaller than the house pipe and 17 or 26 per cent cases, where the house pipe was less than the size of the service pipe. Of the 48 cases where the service pipe was the same size, or smaller, 12 of them or 27 per cent were for $\frac{1}{2}$-inch services with $\frac{1}{2}$-inch house pipes. In round figures about 45 per cent of the complaints are due to too small house piping.

The premises examined showed pressures ranging from 25 to 78 pounds with an average pressure of 43 pounds. From this record it will be seen that the pressure conditions are not altogether responsible for the complaints, and as shown above it is more often caused by the sizes of the house piping or the service pipe, than from the pressure conditions.

The complaints ranged in house size from one-story bungalows to six-story office buildings and in character from lumber yards to sausage factories and hotels to apartment houses.

In conclusion, we believe that a little more coöperation between the plumbers and the water company would greatly reduce the number of complaints of "poor pressure" and speaking for our company we will heartily approve any act that will bring about this coöperation.

WATER SUPPLY AND SEWAGE DISPOSAL OF THE GREAT LAKES CITIES[1]

By Joseph W. Ellms[2]

In 1911, the United States Public Health Service completed a sanitary survey of the entire watershed of the Great Lakes on the United States side of the boundary. This investigation as reported by Dr. A. J. McLaughlin of the United States Public Health Service, stated that "In certain localities on the Great Lakes and in their connecting waters dangerous sewage pollution was shown to exist but the bulk of the Great Lakes waters remains in its pristine purity; that the colon bacillus is practically never present in the unpolluted waters, and that the normal bacterial content of Great Lakes waters is less than 10 per cubic centimeter."

The dangerous contamination of the lake waters arises, of course, from the discharge of sewage from towns and cities located on the shores, from vessels nagivating the lakes, and from surface wash from rains and thaws. The distance polluted water may travel depends upon its volume, the natural currents produced by the flow of waters between the lakes, as in the Detroit and Niagara Rivers, and the currents induced by wind action. It was found that at the mouths of the Detroit and Niagara Rivers serious pollution extended normally more than 10 miles into the lakes, and sometimes was found 16 to 18 miles from the shore. At Cleveland, Ohio, contaminated water may be found at times as far out as 8 miles from the shore.

The high natural purity of the waters of the Great Lakes is, therefore, to a great extent of merely academic interest, so far as a source of water supply is concerned, particularly in the neighborhood of our large cities. The high cost of intake and long tunnels, and the engineering difficulties involved in constructing such works in water over 70 feet in depth, force the conclusion that efficient purification is usually necessary for the maintenance of a safe water supply, and

[1] Presented before the Central States Section meeting, October 9, 1925.

[2] Engineer of Water Purification and Sewage Disposal, Cleveland, Ohio.

that further means for diminishing the load on water purification processes must, in many cases, also be undertaken.

In 1904 the late Prof. G. C. Whipple made an investigation of the sanitary quality of the waters of Lake Erie opposite Cleveland. In 1920 the writer made a similar study covering about 250 square miles opposite the city and its suburbs. Again in 1924 another more limited area of about 36 square miles was investigated for the purpose of locating a new intake. Comparing the results obtained by Professor Whipple in 1904 with those made by the writer sixteen years later, it was evident that the zones of pollution had increased in area, and that contaminated water had forced its way much farther out into the lake. The studies made in 1924 on a smaller area corroborated those made previously.

The economic importance of the Great Lakes in commerce has, in a large measure, been realized. But the natural advantages of these waters as a source of pure water supplies and for recreational purposes have not been similarly appreciated. The natural clarity of these waters for a greater portion of the year led to a belief that they must necessarily be pure and fit for consumption without purification. This idea during the past fifteen years has been gradually changed as a result of the overwhelming evidence obtained in cities located on the shores of the lakes whose inhabitants suffered from water-borne typhoid fever epidemics, and other intestinal diseases. On the other hand, far too little has been done toward diminishing pollution of the waters of the lakes by more complete purification of the sewage discharged into them.

There is no question that the natural resources of dilution should not be availed of; but it should also be realized that there must be a limit to the ability of purification processes to make safe, from a sanitary standpoint, waters which have once been contaminated.

The only source of water supply for cities and towns on the Great Lakes is lake water, and the only place for the ultimate disposal of the liquid portion of the sewage is this same lake water. The question, therefore, arises as to how far can we safely go in disposing of sewage in the lakes without treatment, or even with partial treatment, before the water supply becomes so badly contaminated that purification processes become overloaded. Moreover, is it a proper policy to pursue to encroach too closely upon the barriers set up by filtration and disinfection? Where is the safe limit, from a sanitary standpoint, beyond which it is dangerous to go?

The writer is well aware that the economics of water purification versus sewage treatment need serious consideration in each case. Nevertheless, we do not question costs where life and death are at stake, nor should we do so in this situation. So long as we huddle ourselves together in large cities, we must pay the penalty of concentration. Sanitarians have a grave responsibility in this matter, and they should not shirk it. Too little vision of what the growth of our large cities means is far too common. It is necessary to look forward, and to provide in our engineering structures and in our processes for growth and for concentration of population. If we do not, the evils of insanitary conditions may be upon us before we realize our mistake.

The public are being educated in matters of sanitation and are demanding and will continue to demand more effective measures for the disposal of sewage and of trade wastes, not only for reasons of health, but of ordinary decency.

The cities on the Great Lakes are in a peculiar position regarding water supply and sewage disposal. They are all of them fouling their own nests. Whether they realize it or not, the problems of a safe water supply and the proper and adequate treatment of their sewage are so intimately related that one cannot be solved without solving the other.

RE-LINING THE VERONA RESERVOIR[1]

By Charles L. Crosier[2]

The Suburban Water Company supplies water to the boroughs of Oakmont and Verona, which are situated on the Allegheny River approximately 12 miles north of Pittsburgh, and to parts of Penn and Plum Townships and also to North Bessemer. The works of the Company consist of a pumping station and filtration plant on the east bank of the Allegheny River; the Verona distribution reservoir supplied by two main feeder lines; an 8-inch pipe line leading from the reservoir about two miles northeast to the McAbee booster pumping station; and a distribution reservoir in North Bessemer some two miles further southeast.

The Verona distribution reservoir was re-lined a few years ago and this work is the subject of this discussion.

ORIGINAL RESERVOIR

The reservoir is located on a hill about two miles north of the pumping station and about a mile east of the Allegheny River. Its flow line is at elevation approximately 1100 or about 400 feet above pool level in the river.

The old reservoir built in 1897 was of the earth cut and embankment type, with clay puddle lining and with the side slopes and bottom paved with brick. The reservoir had a water depth of 16 feet, top plan dimensions of 125 feet by 145 feet and a capacity of approximately 1,500,000 gallons.

In 1919 a leakage test was run on this reservoir and the drop in water level was found to be approximately 4½ inches in twenty-four hours. This is at the rate of about 50,000 gallons per day.

RE-LINING THE RESERVOIR

The re-lining of the reservoir was done in the late summer and fall of 1921. The re-lining amounted almost to an entire reconstruction,

[1] Presented before the Central States Section meeting, October 10, 1925.

[2] Division Engineer, Cleveland Office, Morris Knowles, Incorporated, Cleveland, O.

inasmuch as the only part of the old reservoir used was the earth cut and embankment. The brick pavement was replaced with a pavement of reinforced concrete slabs, 6 inches in thickness. The depth of the reservoir was increased by constructing a wall around the top of the embankment, four feet in height. The new reservoir is practically the same size at the top as the old reservoir, being 145 feet 6 inches by 126 feet three inches. This provides a total depth of water of 20 feet and a capacity of approximately 2,000,000 gallons.

DESCRIPTION OF PAVEMENT

The side slopes are divided into slabs 10 feet by 15 feet in size. These were cast separately. These slabs rest on footers and the spaces between the slabs as well as the surfaces between the slabs and footers are either filled or joined with asphalt so as to prevent bond. This is done so as to have definite points at which contraction takes place, to prevent cracking of the concrete. Most of the slope paving slabs were poured with top forms, which were held down by sand bags. Some of the slabs in the corners and a few others were poured without forms, but the concrete had to be rather dry in order to keep it from flowing down the slope, and in general, better results were obtained by the use of top forms. The finishing wall around the top was poured in sections 35 feet long, with expansion joints between sections.

MISCELLANEOUS CONSTRUCTION

A 4-inch open tile drain surrounded by gravel is placed under the finishing or parapet wall around the top; and a similar tile drain is placed at the bottom of the reservoir on its uphill end and sides. These drains are to take care of any seepage which may occur, and the one at the bottom was also intended to take care of seepage from the hillside and a small spring which was encountered at the reservoir site.

A 16-inch line, laid under the reservoir and terminating at the center, serves as both a supply and outlet pipe. This 16-inch line extends about 1 foot above the bottom of the reservoir, so that any mud or dirt settled at the bottom will not be withdrawn into the distribution system. A screen is also placed on the end of the pipe, so as to prevent the entrance of leaves or other foreign matter. This line has an 8-inch connection which can be used as a drain for the

reservoir, by removing a blank flange, as it is placed low enough to drain the entire reservoir.

An altitude valve in the outlet line is provided to prevent the reservoir from overflowing. However, as a factor of safety, in case of failure of the altitude valve to operate, an overflow pipe is provided.

An ornamental fence was provided around the top of the finishing wall. Connection to the wall was obtained by using 2-inch sleeves placed in the wall for a depth of 8 inches, and 8 feet on centers, to hold the posts of the fence.

COST OF THE WORK

The re-lining of the reservoir cost approximately $20,000. As was mentioned before, the only part of the old reservoir that could be used was the excavation and embankment. The amount of material involved in this was approximately 6000 cubic yards, and the cost of the excavation and embankment would be perhaps $10,000. as a maximum figure. Therefore, it may be assumed that the reservoir on the basis of entirely new construction, would have cost approximately $30,000. This gives a reasonable total cost, as it would amount to about $15,000 per million gallons of capacity.

RESULTS OBTAINED

An inspection was made of the reservoir by A. G. Garvin, President and General Manager of the Suburban Water Company, and J. A. Fulkman of this office, in August of this year. It was found that the vertical walls at the top of the slope paving were in excellent condition after four years of service. None of the walls or slopes were bulged or out of alignment. Where certain of the sleeves are inserted for the fence posts there are small contraction cracks, both on the inside and the outside of the wall, extending about 18 inches from the top of the ten inch wall. There are a few points where the sleeves are within a foot or 18 inches of the expansion joints, where the cracks have not occurred. This is, no doubt, due to the sleeves being close to the expansion joints. These cracks might perhaps have been prevented, had there been additional horizontal bars in the wall near the top.

In general, in concrete structures of this nature, as well as concrete roads, it appears that the best way to take care of contraction is by providing a sufficient number of joints. Even then it is not always

prevented, and it may be necessary in some instances, after all due precautions have been taken, to let them crack, just as General Goethals said in reference to the Bigelow Boulevard Slide in Pittsburgh in 1920, "You will have to let it slide."

The Verona reservoir has a pleasing appearance, although it is not in a location where a large number of people see it, and without any special emphasis having been placed on that feature in the design. The finishing wall and the iron fence around the top add materially to its appearance. Such a finishing wall has a decided advantage where a reservoir has to be built in a location of limited area, as it adds capacity without increasing either the slopes or the surface area. Reservoirs of this type can be built in high class residential districts, in parks or at country clubs, as the presence of such a body of water adds to, rather than detracts from, the appearance of the landscape.

ALGAE IN WATER SUPPLIES[1]

By N. L. Huff[2]

The algae of our water supplies are minute forms of plant life, often too small to be seen with the naked eye. In structure they rank among the simplest of plants, yet in their conquest of the earth they have been preeminently successful. They are found in lakes and rivers, ditches, ponds, reservoirs, in fact wherever natural waters are exposed to the light. In the economy of nature they play an important rôle for they are the ultimate source of food for practically all of our fish and other animal life of pond and stream. In small lakes and reservoirs, however, there is often an over-production, they form offensive accumulations and may even become a menace to public health.

In large and deep lakes where the temperature is low the water may be almost of crystal clearness, yet a plankton net drawn through the water, or a fine sand filter will separate out countless millions of these minute organisms. But it is in shallow lakes and sluggish streams where the water reaches a high summer temperature that they find conditions most favorable for their growth and development. It is here that they form massive scums and ill-smelling slimes so familiar to all who have had experience in storing water in open reservoirs and small lakes.

When present in small numbers algae are not injurious to health nor are they particularly objectionable. If abundant, however, they not only become displeasing to the eye, but certain forms produce offensive tastes and odors that render the water unfit for domestic use. The troubles caused by these aquatic plants are universal. Not only do they produce greenish or brownish colors and a turbidity highly objectionable, but tastes and odors in water supplies can more often be traced to algae than to any other source.

Attempts to classify tastes and odors caused by algae have been

[1] Presented before the Minnesota Section meeting, November 13, 1925.

[2] Assistant Professor of Botany, University of Minnesota, Minneapolis, Minn.

numerous but never, I think, very successful. Such terms as musty, aromatic, woody, and grassy are often used to describe the odors of certain algae, but these terms are rather vague and not therefore very satisfactory. In some cases living algae have a characteristic odor especially when present in great quantities. Certain diatoms when abundant may impart to the water a fishy odor and it seems probable that this odor arises from the living organisms rather than from the few dead or disintegrating forms that may be present. Some of the blue-green algae have an odor when living and growing that is decidedly characteristic, and very different from the offensive odors given off with disintegration.

Algae most troublesome in water supplies fall naturally into two large groups, the *green algae* (Chlorophyceae), and the *blue-green algae* (Cyanophyceae). The first of these groups is the less objectionable of the two and for our purpose may again be divided into three groups. One of these consists of unicellular and colonial forms of bright green color, usually free-floating, drifting with the water currents but remaining within a few feet of the surface. Members of this group often impart a greenish color to the water, but they seldom form scums and are not often present in sufficient quantities to be highly objectionable. The second group of green algae, including the filamentous forms, is more objectionable. Members of this group do not ordinarily produce odors, but they accumulate in filthy-looking masses forming scums that are unattractive to say the least. Some of these have attachment organs by means of which they cling to stones or submerged water-weeds and so long as they remain completely submerged are not highly objectionable. Often however they form tangled masses which break loose from their moorings and come to the surface where they continue to thrive for the rest of the summer. Other forms have no attachment organs and from the beginning are free to form objectionable surface scums.

As a result of certain life processes green plants give off oxygen when growing in the sunlight. In submerged filamentous green algae this gas often collects in the meshes among the filaments until the whole mass is buoyed up to the surface forming the familiar scums. If no pond-weeds or other plants are present to support the mass at the surface it may settle to the bottom at night or when the oxygen in the meshes among the threads has escaped. But the light of another day will generate more oxygen, and again the mass will rise to the surface. Sooner or later the raft-like mass drifting hither and

thither with winds and waves may find anchorage among the stems of pond-weeds or bulrushes and here it may continue to thrive as a pond-scum for the remainder of the season. Algae of this type are comparatively long-lived, a given individual may persist for the entire season. They are practically odorless and even at the end of the season when they die and disintegrate the process is a slow gradual one and is not accompanied by disagreeable odors as in case of the blue-green algae. From the aesthetic point of view however they are highly objectionable, and should be eliminated early in the season, or whenever they begin to form conspicuous scums on the surface.

The third group of green algae troublesome in water supplies is that very large and widely distributed group known as diatoms. They are unicellular forms, often held together loosely in colonies, sometimes attached to water-weeds, stones or other submerged objects, but the most troublesome forms are free-floating. The specific density of diatoms is nearly the same as that of water in which they live and they seldom form scums, but during the summer months may be evenly distributed through that stratum of water which is agitated by winds and waves. In our small lakes this means that they are commonly distributed to a depth of about 20 feet. Below this depth the water is stagnant during the summer and diatoms in this stagnant water are rare or absent. Unlike many of the scum-forming algae that thrive only during the warmer seasons, some diatoms are far more abundant in the cool waters of spring and autumn than during mid-summer.

The green coloring matter of diatoms is commonly obscured by a brown pigment so that when abundant they impart to the water a muddy brownish color. Under conditions most favorable for their development the water may become so turbid that light-colored objects become invisible a few inches below the surface, and the fishy odor characteristic of diatoms may become quite offensive. Not only is such water unsuitable for ordinary domestic use, but on account of strains produced it is unfit for use in laundries or for the manufacturing of paper.

The algae most detested as contaminators of public water supplies belong to that universally distributed group, the blue-green algae. They are minute plants of very low organization, often single cells existing alone. Others form long chains or threads, still others form colonies with thousands of individuals held together by a watery gelatinous matrix. Some of the filamentous forms cling to the mud

or stones in the bottom, but most of the colonial forms are free-floating and being lighter than the water tend to form scums on the surface.

The method of reproduction in these unicellular forms consist in a simple cell division, so that each division results in doubling the number of plants. These divisions occur in rather rapid succession, only a few hours being required for an individual to complete its life cycle. The total number of individuals is doubled or trebled every twenty-four hours, and this rate of increase may continue for several weeks during the summer. The number of offspring arising indirectly from a single individual during a summer is almost inconceivable. Allowing a conservative time of twenty-four hours for an individual to complete its cycle and divide, the offspring from a single individual would in thirty days number 1,073,741,824, if all the offspring matured and divided. Microscopic examination and daily counts from lakes where conditions were favorable for their growth and development, show that they actually do increase at times for a period of several weeks, at a rate in excess of this theoretical case. The fact that not all individuals mature and divide to form two new ones is more than compensated for by the fact that many complete their cycle in considerably less than twenty-four hours.

The cells of these blue-green algae are exceedingly delicate and fragile and it is evident that where multiplication is so rapid the mortality rate is going to be high. Even when living and growing some of these forms are known to emit a disagreeable odor fittingly described as a "pig-pen" odor, but with death and disintegration the odors are intensified and become exceedingly offensive. When abundant they produce scums like green paint or Paris green and with favorable winds their odors may be detected a half mile or more from the lake.

How can we prevent or control the growth and development of these objectionable organisms in our small lakes and reservoirs? The most effective method known at the present time consists in the application of copper sulphate in quantities sufficient to destroy the algae, but not large enough to prove objectionable from the standpoint of the consumer. But when and how shall this application be made to obtain the most satisfactory results and avoid certain objectionable features such as disagreeable tastes and odors resulting from the algae destroyed?

The method of distributing the copper sulphate in lakes and reser-

voirs by dissolving the crystals out from coarse sacks towed behind boats is quite satisfactory and is too well known to need further description here. There are cases, however, where the trouble is caused by definite scums where spraying is a more effective method of treatment.

In regard to the amount of copper sulphate necessary to keep a reservoir free from algae, no rule can be given. The various species of algae are not equally sensitive to copper, in fact some species are very resistant to its effects. Even for a given organism the quantity necessary for its destruction is affected by the water temperature, the amount of organic matter dissolved or suspended in the water, the hardness of the water, and several other conditions. The whole matter is complicated and each case requires particular study and a specific prescription.

A knowledge of the nature and life-habits of the organisms causing trouble is always desirable, in fact is essential if one would use copper sulphate most effectively. Let us consider briefly some of the habits of a few common typical forms:

The unicellular green algae are not as troublesome as some others, but occasionally they become sufficiently abundant to impart a greenish color to the water. They vary greatly in form and size. Most of them reproduce by division of the cell into two, but some of them form complete little colonies within the parent cell. Some reproduce sexually and form heavy-walled resistant resting spores. The Desmids are of varied and artistic design, usually constricted between the two half-cells. They occasionally form resting spores but more commonly form new individuals by division of the old cell into two. Copper sulphate is most effective if applied during the period of great vegetative activity. The resting spores are probably not affected by small quantities of copper sulphate that prove fatal to the actively growing cells.

Pediastrum is sometimes very abundant in shallow lakes with muddy bottoms. It consists of a colony of individuals arranged in a beautiful design, radially symmetrical. Each individual is independent of the others and may form within itself an entire colony of new individuals.

The water-net (Hydrodictyon) consists of cylindrical thread-like segments connected up to form a lace-like net, often several inches in length. These nets, while very beautiful when viewed with a lens or microscope, float on the surface in great tangled masses and

form unsightly scums where conditions are favorable for their growth. They reproduce by forming an entire new net within each segment of the old net, or by a sexual process which results in the formation of a resistant resting cell or spore-like body that carries the plant over winter. When the water-net is free-floating it is very sensitive to copper sulphate; when lying on the mud of the bottom it seems to be very resistant. The probable explanation for this lies in the fact that the abundant organic matter in solution or in suspension near the bottom consumes the copper before it actually reaches the living cell.

Cladophora is one of the most common of our scum-forming green algae. It consists of rather coarse, profusely branched threads and is often attached to some submerged object. The green mossy growth seen in running streams and under water-falls is often due to this plant. In lakes and ponds it often breaks away from the substratum and forms great raft-like masses that float about the surface or lodge among pond-weeds near the shore. This form is very resistant to copper sulphate, requiring ten times as much of the chemical for its destruction as do many other forms. Fortunately it is most objectionable when it floats on the surface and forms scums, and in this condition it can be destroyed by spraying the surface of the water with a strong solution of copper sulphate. Since the scum at the surface receives the full effect of the spray, this resistant form may be destroyed while more sensitive species at greater depths may escape injury.

Perhaps the most common of all our scum-forming green algae is Spirogyra. It consists of long, unbranched, silky threads, soft and slimy. Under the microscope we see its cylindrical cells arranged end to end, each with one or more green ribbon-like bands wound spirally within the delicate transparent wall. The reproduction in this plant is usually sexual, the male and female gametes from different cells uniting to form a heavy-walled resistant spore which carries the plant over winter. Spirogyra is one of the most sensitive of our algae to copper sulphate, one part in ten million being sufficient to destroy most of our common species. To be most effective the copper sulphate should be applied during the growing period preceding reproduction. The resting spores are not affected by ordinary copper sulphate treatment of the water.

Pond-felt (Vaucheria) is more commonly found growing in the bottom of ponds and springs, in shallow water. Its filaments are

branched, but not segmented. Its common method of multiplication is by means of motile, non-resistant, spore-like bodies, but at certain seasons it too forms the resistant resting-spore to carry the plant over winter.

The diatoms constitute an interesting group of organisms. Each individual is one-celled and is enclosed in a transparent, siliceous, glass-like wall consisting of two valves one overlapping the other like a pill-box and cover. The valves are marked or sculptured with numerous regular transverse lines. Some species grow on stalks, attached, others solitary or in colonies. In form they vary greatly, rods, cylinders, disks, wedges, or boat-shaped, but all are of definite geometrical design. This most common method of reproduction consists in cell division, a process in which the two halves of the siliceous wall separate from each other and each forms a new half. Some species however may give rise to a very large number of minute individuals within the wall of the parent cell. These are liberated and develop rapidly into the adult form. During the summer months when the water temperature is high (60° to 80°F.) these may respond quickly to copper sulphate treatment, but during the spring and autumn overturning when the water temperature is low and great quantities of dissolved or suspended organic matter are present in the water, they are but little affected by heavy treatments of copper sulphate. They may normally disappear soon after the period of circulation has passed and it is doubtful if a moderate quantity of copper sulphate will hasten their disappearance at this time.

The blue-green algae are very common and are most fragile and most objectionable of all our water-supply algae. A drop of water taken from near the surface of lake or pond may, under the microscope, show thousands of individuals representing many different species.

Clathrocystis consists of single cells held together loosely in colonies by a gelatinous matrix. Reproduction consists in simple cell division, and the rate of increase is very rapid in warm weather when conditions are favorable. Heavy-walled resistant spores are not formed so far as known, and elimination of this species with copper sulphate is comparatively easy.

In Oscillatoria the disk-like cells form threads the ends of which commonly oscillate through a small arc when the plants are actively growing. In Lyngbya the cells are disk-like but a heavy sheath is present and movement is lacking. Both of these forms are more

commonly found in the bottom in shallow water, and they thrive best in the presence of sewage or decaying organic matter, but occasionally cause trouble in public water-supplies. They do not produce heavy-walled spores and are responsive to moderate quantities of copper sulphate.

Anabaena, one of our most troublesome water-supply algae, is represented by several common species. Its cells are joined in chain like chains of beads. Its increase during the summer is due to a rather rapid division of its cells and threads, but it forms heavy-walled resting spores for carrying the plant over winter. It is one of the most sensitive of algae to copper sulphate, but for best results it should be destroyed before the spores are formed.

Aphanizomenon sometimes becomes very abundant in certain lakes, but is less common than Anabaena and Clathrocystis. Its filaments are arranged in loose bundles but with little agitation of the water these bundles are broken up. It has less of a tendency to form scums than other troublesome forms but gives a blue-green color and a turbidity to the water. It is carried over winter by heavy-walled resting spores.

In Rivularia we have a tapering thread resembling a whip-cord in form. The resting cell is formed near the basal end. This form grows in colonies that float near the surface and is commonly found along with Anabaena and Clathrocystis.

All of the blue-green algae which cause trouble in our water supplies are sensitive to copper sulphate and disappear within three or four days after treatment. The disappearance of course is due to the complete disintegration of the plants, and since decay of organic matter is usually accompanied by the liberation of gases, and the gases here liberated are ill-smelling, best results are obtained by treating as soon as they have begun their rapid multiplication, and before heavy scums have been formed. The destruction of small numbers of algae, even such forms as Anabaena and Clathrocystis is not accompanied by odors that can be readily detected, and if the treatment is made at the proper time there should be no ill after-effects. It is the delayed treatment that is followed by objectionable features. In case of spore-forming species the best results are obtained by treating before the spores have been formed, since resistant spores may not be affected by the copper sulphate that would destroy active plants.

In all cases where troubles frequently arise from algae, microscopic

examination of the water should be made daily by one who understands the organisms and their habits of life. Any tendency on the part of troublesome forms such as Spirogyra, Anabaena, and Clathrocystis, to increase rapidly should be checked at once by the proper application of copper sulphate. If this is done there can be no serious after-effects of odors and tastes due to accumulated masses of objectionable algae.

SERVICES AND METERS[1]

By E. V. Buchanan[2]

Water works in London, Ont., were established in 1878. The source of supply was then entirely from springs, and remained so until 1909, when the original source was augmented by artesian wells. The water is comparatively hard, the total hardness being in the neighborhood of 30 grains per Imperial gallon. Otherwise the supply is excellent, being pure, clear, and palatable.

It has always been the practice of the water works department to lay small services free of charge to a point 20 feet inside the street line, at the same time providing curb cock and box, cellar hydrant, and meter. The original domestic service was lead pipe $\frac{3}{8}$ inch diameter, which was later abandoned and $\frac{1}{2}$-inch pipe adopted. The first $\frac{1}{2}$-inch pipe used weighed 5 pounds per yard, but for many years only pipe of 6 pounds per yard has been used. The consumer pays the total cost of the larger services except that an allowance is made for the cost of a $\frac{1}{2}$-inch service, if the small service has not already been laid on the lot. The average length of services is 60 feet, there being many streets of 132 feet in width and also the 20-foot allowance on the owner's property to consider. The average cost of labor and material is $30, but the consumer is charged 55 cents a foot for all pipe over the 20-foot allowance.

PROTECTION FROM FROST

It has been the practice until recently to lay all services before pavement is put down, as public sentiment is very strongly against breaking up asphalt and concrete. It has been found, however, that with the main laid in the boulevard, services can be pushed under the pavement by means of a pipe-forcing jack and using lead-lined wrought iron pipe. The laying of services in advance of the pavement is usually a great waste, as lot lines are subject to change and the unused services are left to break away and leak.

[1] Presented before the Canadian Section meeting, March 5, 1926.

[2] General Manager, Utilities Commission, London, Ontario.

Services like mains are laid with 5-foot cover and very little trouble is experienced from freezing. There has been one or two years of severe cold when there has been an epidemic of frozen services. In these cases, the electrical department has done good work in thawing by electric current. The greatest amount of trouble occurred on streets that had been re-graded after the services had been laid. Now-a-days, the city engineer gives permanent grades, which prevents expense in lowering mains and services. No services that the department has laid have been frozen in the past five years, although some freezing has taken place on service pipes extended by the consumers themselves. With all services metered, it is practically certain that taps are not being allowed to run to prevent freezing, and this proves that the pipes are well below the frost line. Services are always laid to the lot from the street on which the house faces, and driveways are avoided. Records are made on cards giving the location of the curb cock by reference to the two street lines.

SIZES OF LEAD PIPE

Lead pipe has always been used for $\frac{1}{2}$-inch, $\frac{3}{4}$-inch and 1-inch services. For 2-inch galvanized wrought iron is used, and cast iron for 4-inch and larger.

The water being hard does not occasion any trouble from lead poisoning, and little or no deposits are formed on the pipes. Pipe removed after forty years' service is found to be quite clean.

There has been some discussion recently regarding the size of domestic services, but, although the ordinary pressure in some districts is quite low, averaging about 40 pounds, few complaints are heard. Automatic water softeners and flushometer toilets seem to call for larger services, but the trouble in these cases, where the service pipe has already been laid, can probably be overcome by means of a tank partly full of air.

Tapping machines are always used for inserting the corporation cocks in the mains. These cocks are usually inserted at an angle of 45 degrees, which gives a good "get away" for the lead pipe. The corporation cocks are provided with a lead flange coupling and lead goosenecks are used in the case of wrought iron pipe services.

The standard curb cock box is a Buffalo type box, made locally.

The curb cock with a lead flange coupling is used, the cock with the lead pipe bushing and rubber washer being abandoned some years ago on account of trouble with the washer. The curb box and cock rests on a pine wood block, $1\frac{1}{2}$ inches by 8 inches square, which holds the cock fairly securely in place. Cocks with stop checks are preferred.

Before the installation of meters, it had been the practice to use cellar hydrants with a hose connection, but following the use of meters it became necessary to install the meter on the street side of the hydrant to prevent the unauthorized use of water from the hose connection. This was an unsatisfactory arrangement as the cellar shut-off should be as close to the service entrance as possible, and should also control the meter. An ordinary stop and waste cock is now used and is much cheaper to install than the old type. All brass work is tested on a test bench to 175 pounds per square inch.

In new subdivisions where there is plenty of space and no obstructions, the "Buckeye" trenching machine can be used to advantage to do the excavating, but generally speaking, it is too unwieldy. It is said that smaller ditching machines on the market can do this work economically in nearly all locations.

A steel point on the end of a 1-inch pipe was at one time used successfully for driving distances of not more than 12 feet, but a pipe-forcing jack is now used with a 1-inch pipe, which is withdrawn, and the lead then passed through. In the majority of districts it is possible to force lead-lined galvanized iron a distance of over 24 feet. This, of course, is not withdrawn, but is used as the service pipe.

The men of the service gang are taken to the job along with the material, on a 2-ton truck. The foreman makes out cards showing the time of men, and all material used. The amount of material and labor to be charged the consumer is also recorded, as well as the measurements for locating the curb cock. The service installation order from the general office is returned from the workshop when the job is complete, giving all of the above information.

When applications are made at the office for services for vacant lots, the applicant is given a small sign mounted on a spike which he drives into the ground on the line on which he prefers the service and on the building line.

ESTIMATES FOR COPPER PIPE

As much interest has been created by the suggested use of copper pipe, the following estimates have been made:

60 feet of ½-inch lead pipe	$16.50
½-inch corporation cock	1.03
½-inch curb cock	1.79
	$19.32

60 feet of ½-inch copper pipe	$ 9.44
½-inch corporation cock	1.03
½-inch curb cock	1.79
Two ½-inch copper-to-copper couplings	1.14
	$13.40

60 feet of ⅝-inch copper pipe	$11.10
⅝-inch corporation cock	1.32
⅝-inch curb cock	2.43
Two ⅝-inch copper-to-copper couplings	1.53
	$16.38

It is seen that there is considerable advantage in price in favor of the copper, as compared with lead. The chief objection to lead is its common failure when a sewer or other ditch crosses its line, and no doubt copper would withstand extraordinary stresses better. Tests show that London water does not dissolve or produce any appreciable chemical action on copper. Although no figures are available, it would appear that the loss of head is no greater for copper than for lead, and as the bore is more uniform the friction loss would probably be less. In addition the figures show that ⅝-inch copper can be laid for less than ½-inch lead.

Records of the prices of copper and lead over a period of 15 years show that copper is in a most favorable position. Since 1916 the price of copper has fallen steadily and in the past year has been around pre-war prices. Lead, on the other hand, has been steadily rising since 1921 and is now practically as high as it has ever been. If these conditions are abnormal, as they appear to be, then the advantage of copper pipe from a price point of view may soon disappear.

REASONS FOR METERING

There are two reasons for the use of water meters. The first is that selling water by measurement is the only logical and fair way of conducting the business. The second is that the water meter is the only practical method yet found for restricting excessive waste.

London has for many years metered nearly all industrial and commercial consumers, and has also had a considerable number of domestic meters in use for a long time. Formerly the practice with meters was to place them on request by the consumer, which was a foolish

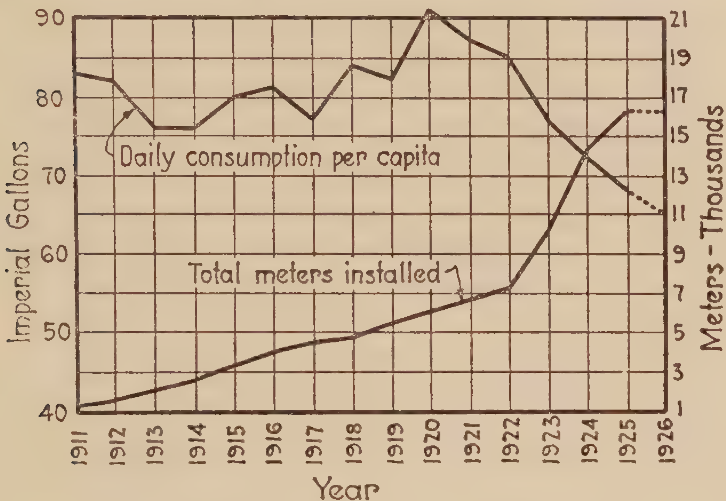


FIG. 1. RELATION OF METERING TO CONSUMPTION

policy, because the consumer who asked for a meter was naturally a careful user, so that no water was saved, the cost of supplying him was increased by the cost of the meter and its maintenance, while in the case of the larger houses the revenue was actually reduced. Four years ago a general policy of metering was adopted, which was practically completed at the end of 1925.

Ten-year debentures were issued for the purpose of financing the scheme, and Canadian-made meters were used entirely to complete the work. The cost of the meters installed averaged $14.

It is difficult to deduce accurately the saving made by the installation of meters, because of varying conditions from year to year.

The lack of rain, the different summer temperatures, and the varying degrees of cold in the winter, all affect the consumption. Changing conditions in business, affecting the number of vacant premises, and the growth in the number of consumers are all factors. Figure 1, however, shows in a general way what has been accomplished. The per capita consumption reached 91 Imperial gallons in 1920, and this year it is hoped it will not exceed 60. The city was supplied from Springbank Station alone until 1909, when there were serious water shortages and when the wells were added, which have been pumping between one and three million gallons a day. In the autumn of 1925 it was found possible to operate with Springbank Station alone, whose capacity is just under three million gallons a day. The water drawn from the reservoirs during the week is replaced by pumping the wells on Saturday afternoons and Sundays. It is interesting to recall a report made to the city by Willis Chipman in 1903, who said: "By the adoption of meters the present supply should be sufficient for all purposes for a population of 55,000." It is easily seen how nearly correct he was, as the city population is now 64,000.

The total pumpage during the months of November and December, when 97.1 per cent of consumers were metered, is accounted for as follows:

	GALLONS	PERCENTAGE
Total pumped	202,284,000	
Water passed through meters	167,236,875	82.7
Estimated consumption, flat rate	4,240,000	2.1
Estimated water for meters out of service or under-registering	4,248,000	2.1
Consumed in iron-removal plant	3,050,000	1.5
Flushing streets	2,756,250	1.3
Drinking fountains and miscellaneous	1,220,000	0.6
Unaccounted underground leakage, etc.	19,532,875	9.7
	202,284,000	100.0

METERS REDUCE CONSUMPTION

The effect of rates on consumption may be interesting. Until 1925 two rates were in use: (1) A flat rate based on the size of the house and the number of conveniences installed; (2) a sliding scale meter rate with a minimum charge. The sliding scale did not affect

the domestic consumer, as the first change did not come until 10,000 cubic feet had been consumed in two months. The minimum charge for a domestic consumer was $1.35 net for two months, and allowed 800 cubic feet of water. This is more than 80 gallons per day and the great majority of domestic consumers do not require this amount.

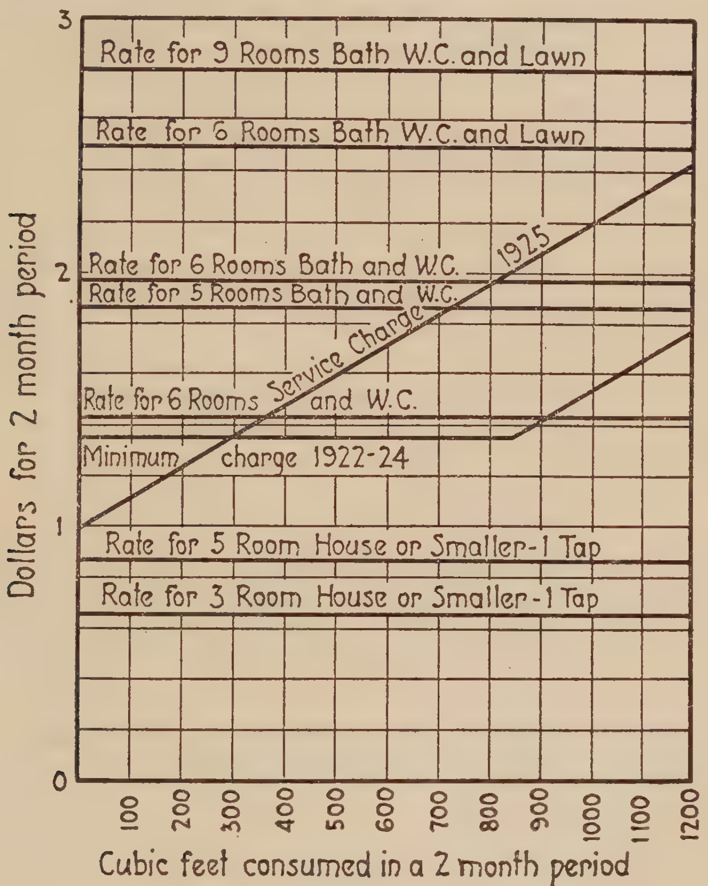


FIG. 2. BI-MONTHLY CONSUMPTION, LONDON, ONT.

The minimum rate was replaced at the beginning of 1925 by a service charge rate, the service charge being $1.00 net for two months. The consumption rate remained the same, viz., 12 cents net per 100 cubic feet. The records for 1925 show that 65,000,000 gallons less passed through the domestic meters than in 1924. or over 12 gallons

a day for every meter. When every drop of water recorded by the meter must be paid for, economy follows immediately. Figure 3 shows the rates which have been used in London, and figure 2 shows the number of bills rendered for varying quantities of water.

Meters ⅝-inch size are used on practically all domestic services, and even on domestic services as large as 2-inch, meters of ¾-inch and 1-inch are usually found to be sufficient. As a rule it is found that error is made through installing meters that are too large. By noting the highest consumption over the meter-reading period it is found that the size of the meter can be reduced, and if the reduction does not affect the pressure on the consumers' premises he does not usually object as the service charge is based on the size of the meter and rises rapidly. Meter readings are made every two months on all meters up to 1½-inch. The larger meters are read weekly, so that any stoppage or excessive consumption can be quickly checked.

The type of meter for the smaller sizes up to 2-inch has always been the displacement type. Although in the past even the larger meters have all been of the single unit current type, it is now the practice to use only compound meters for sizes 3 inches and over. No meters are placed on fire service lines.

METERS TESTED FOR ACCURACY

When meters are received from the manufacturer or are brought in for repairs or for any other reason, they are tested for accuracy within and as near as practicable to the low and high rates of flow. A test is also made for minimum flow. If meters are found inaccurate, they are adjusted, and if found that they cease to register on small flows, are repaired and adjusted. The ⅝-inch meters must register water passing through a $\frac{1}{64}$-inch orifice at 65-pound pressure. The meter with this orifice records one cubic foot in two hours and fifty minutes. It is more important that a meter should be sensitive than that it should have a high degree of accuracy. Compound meters are tested within the "change-over" range, as well as at high and low rates of flow. A test made recently on a 4-inch compound meter removed from service showed the following results:

2-inch orifice, 100 per cent	⅝-inch orifice, 95.0 per cent
1½-inch orifice, 98.5 per cent	½-inch orifice, 94.0 per cent ("Change-over" point)
1¼-inch orifice, 98.5 per cent	¼-inch orifice, 98.5 per cent
1-inch orifice, 98.0 per cent	⅛-inch orifice, 98.5 per cent
¾-inch orifice, 97.0 per cent	

It will be seen that the accuracy falls off rapidly from the 1-inch stream down to the "change-over" point between a $\frac{1}{2}$-inch stream and a $\frac{1}{4}$-inch stream, and is more or less restored beyond this point.

It has been necessary with the adoption of the general metering to have a systematic re-test period. There is no use metering a system unless the meters are properly maintained, tested and adjusted. The periods decided on are as follows:

$\frac{5}{8}$ inch,	5 years	3 inches,	2 years
$\frac{3}{4}$ inch–1 inch	4 years	4 inches–6 inches,	1 year
$1\frac{1}{2}$ inch–2 inches,	3 years		

RE-TESTING PERIODS FOR METERS

The re-test period might be more accurately fixed by the actual duty of the meter than by the number of years in service, and it is

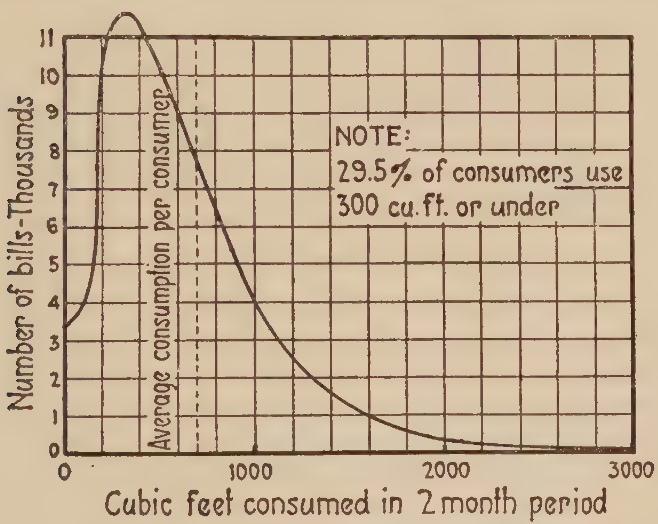


FIG. 3. WATER RATES, LONDON, ONT.
Based on $\frac{1}{2}$-inch meter, with 20 per cent discount

suggested that no meter remain in service without re-test after the register has performed one complete cycle. Meters taken out for re-test after periods of use as great as fifteen years, show great accuracy at high rates of flow, but invariably it is found that these meters are not registering low rates. In fact, $\frac{5}{8}$-inch meters have often been found to fail to register the flow through a $\frac{1}{8}$-inch orifice.

As mentioned previously, sensitiveness is infinitely more important than high accuracy.

The 3-inch, 4-inch, and 6-inch meters can be easily checked for large rates of flow on site by means of a Pitometer, and with cocks inserted on both sides of the valve, the low rates can be checked by using a small test-meter between these two points with the valve closed. The smaller meters are always removed and tested in the shop. When a consumer complains of a high bill and attributes it to a meter over-registering, a test is made on site in the presence of the consumer, with portable test-meter. If the meter is once removed from the premises it is impossible to convince the consumer that the meter was right.

In the workshop all meters are tested for the higher rates of flow on a Mueller meter-tester, the amount of water passing through the meter on test being weighed. For testing $\frac{5}{8}$-inch meters for minimum and small rates of flow, a test bench has been constructed to test 9 meters in series.

Meter record cards are kept for every meter, giving the make, number, size, date received, test, cost installed, date installed, consumer's name and address, and meter reading. On the back of the card the changes and repairs are shown, giving dates, causes, tests, and cost of repairs.

METER-INSTALLING METHODS

When meters were being installed wholesale, the men, meters and other material were taken out in a Ford "light delivery" truck and a trailer, which was parked as close as possible to the center of the installation area for that day. Between 6 and 7 meters a day were installed by each man, working nine hours a day. The foreman of this gang checked all installations for workmanship and also examined the house plumbing for leaks, notifying the consumer if any were found. He makes out a card giving all the information, which is in turn entered on the office card previously referred to.

In the case of houses with no basements, or for outside hydrants, an outside meter box is installed. The box is made up of 4 feet of 15-inch glazed tile. The outer cover is of cast iron and fits snugly in an iron ring which flanges over the outside of the tile but does not project inside, thus leaving an unobstructed opening for the inner cover. The inner cover, to make the box frost proof, consists of a

wooden disc on which is nailed a piece of felt 18 inches in diameter and $\frac{5}{8}$ inch thick. When this cover is inserted in the tile, the felt is turned up around the edge of the wood, preventing the warmer air from the ground from escaping or the cold from penetrating from above. The meter is supported on galvanized iron pipe brought up to a point 18 inches below the ground level. The cost of this box with meter installation is $11.75. The consumers are charged $10 cash. The difference is an allowance for the cost of the saving of the inside installation. As most of these boxes are installed for owners of poorer houses, installments of $1 bi-monthly for two years are accepted.

With the larger variation in the number of meters handled, it is difficult to give a fair average figure for the cost of maintenance, but our records show this cost to be about 80 cents per year per meter. The figure is probably high because of an accumulation of work in recent years, and is averaged over a period of high prices.

The consumer is charged the full cost of all repairs made to a meter damaged by hot water or other causes not under the control of the department, except in the case of frozen meters, when a flat charge of $2.50 is made.

For a time the well water contained a high iron content, and deposits in the meter caused trouble. The installation of an iron-removal plant eliminated this trouble and the meters are now singularly free from deposits or corrosive action of any kind.

This paper is written more with the idea of bringing up topics for discussion than with the intention of offering advice on methods of practice. Although the water works problem is a very old one, dating back two thousand years, to the days of ancient Rome, there is an unfortunate lack of standardization as compared with that very modern public utility, electrical supply. The American Water Works Association is rendering a service of infinite value in this respect, and I am deeply indebted for the opportunity of contributing to the proceedings of the Canadian Section in a very humble way.

DISCUSSION

C. G. Routledge: I haven't very much to add with regard to Mr. Buchanan's paper. It was a very interesting one and I am just going to make a few comparisons between the methods we adopt in Toronto and the methods adopted in London. In Toronto we

install water services to the street line only. Lead pipe is used for services $\frac{1}{2}$ inch to 1 inch in diameter and is laid at a depth of 6 feet. From the street line to the building the owner constructs the service, supervised regarding material and depth by the Medical Health Department. At the street line a wiped joint is made by the owner, which occasionally is the cause of trouble afterwards. If the owner desires to avoid this joint, we leave a coil of lead pipe at the street line sufficient to reach to the building, provided the building is not a greater distance from the stop-cock than can be reached by a coil of pipe usually supplied by manufacturers. The cost of the extra pipe left at the street line is paid for by the owner when he pays for the service installation.

The installation of lead services is charged the owner on a flat-rate basis, assuming the main to be in the center of the street, but the actual cost is charged for the installation of services over 1 inch in diameter.

Galvanized iron is used for 2-inch services, and cast iron for services of larger diameter.

The location of stop cocks and valves on services is fixed by two measurements across the street, one from the curb, and one from the building, fence or street line. Two measurements are also taken longitudinally on the street, one from the line of the side of the building nearest the valve, and one from the street line of the nearest intersecting street.

These measurements, together with the size and date of installation of the service, are entered in loose-leaf ledgers alphabetically with regard to the name of the street, and numerically according to the number of the property on the street.

With regard to a service charge, I am personally in favor of it, based on the average cost of maintaining the particular size of service; also a meter service charge based on the average cost of maintaining the particular size of meter.

I am also inclined to a minimum charge for water, in order to remove the tendency of some people, when they have to pay for every drop of water registered by a meter, to deny themselves enough water for sanitary purposes and the maintenance of lawns and boulevards in decent condition.

As Mr. Buchanan has considered these points carefully, no doubt, I would like to have his views regarding them, particularly what he

considers the best way at arriving at a fair service and meter charge, and also a minimum charge for water.

With regard to meters, I have done my best to understand them and am still struggling with the problem. I am not clear what Mr. Buchanan means by a "high degree of accuracy." My conception of it is 100 per cent from a rate of a drop per minute to the capacity of the meter—no bobbing up at some point in the line and no dropping down at either end.

The performance of each make of meter with regard to the closeness it will register 100 per cent of the water passing through it at all rates of flow within the range of its capacity, both when the meter is new and during its service life-time, is, in my opinion, well worth studying.

The high points in meters are sometimes the cause of rather serious trouble between the consumer and the water works department, and the low points result in loss of revenue to the water works.

Personally I do not think that any meter should be placed on a service which at any point within its range registers more than 100 per cent.

I think it is very important that large meters should be tested at various rates up to about their capacity, both when new and after repairs, in order to make sure that they are in good working order.

In Toronto a calibrated tank of 5000 Imperial gallons capacity is used for this purpose.

C. J. Pratt: I would like to ask Mr. Buchanan what is the average life of a ½-inch meter?

F. B. Goedike: Our Water Works Department is in a rather ragged state and I am going to have some time getting it into proper working order. Our charges are based on the same principle as the City of Toronto. Our mains are constructed under the Local Improvement Act and charged directly against the property. We have a ½-inch service into each house, which we charge for, after the first 20 feet from the street line. I am not familiar with the cost as that comes under the revenue department. We have installed a number of copper services. I cannot say at present just how they are working. We have in the neighborhood of 8000 meters. We are putting them on as fast as we can get them. The meters are

placed in the houses where there is no danger of frost. Where we find the amount of water used in a house is not excessive, and that it is too expensive to keep the meter there, we take the meter out. We have a number of small three and four-roomed houses that are not metered.

A. H. R. Thomas: In New Toronto we do not meter anything at all outside of factories, therefore our proposition would not be of much interest.

The Chairman: Are you using copper pipe or lead pipe?

A. H. R. Thomas: We are using lead pipe, although we are thinking of changing to copper pipe owing to the expense of lead. We put in ½-inch services.

Geo. Fisher: I feel rather out of place in making comments to this convention. As a manufacturer and also a meter user, I do believe that this is a live subject. I do not say that it is possible to eliminate the ½-inch service, but I believe that it should be given serious thought. I would like to ask Mr. Buchanan why he uses galvanized service pipe when his lead pipe does not show any deterioration in forty years?

E. M. Proctor: There are a couple of points in connection with this discussion that I would like to enlarge on. We hear so often the question of the per capita consumption of water, and it varies so much from place to place. It seems to me that if somebody would figure it out and bring it down to a standard, we would get some place. With a standard pressure of 40 pounds, you will have a certain water consumption, and if you put in a pump and raise that pressure to 60 pounds, your water consumption immediately jumps. The percentage of houses that are connected directly to the sewer is a very great factor in increasing the consumption of water. A municipality will get along with thirty gallons per capita, but immediately they put in sewers it will jump up to 60, 80 or sometimes 100 gallons per capita. That is a very important factor when you are talking about the per capita consumption. I think that has a great deal to do with why the figures are different in some places.

I am very much in favor of water meters. It is not only the

saving you have in your water, and it is not altogether capital cost of the meters, but some day you may have a shortage of water. And another important matter is that if you increase your water consumption, you also increase the amount of flow that enters your sewer system. So that if you decrease the cost of the water works plant, you also make a reduction in the cost of the sewage plant.

I am very much with Mr. Buchanan in regard to water rates. I think the service charge is right, and then charge the consumer for the water he uses after that. If you have any reductions to make in the water rates, take it off the cost of the water and leave your service charge to cover your capital cost.

I think there is very little difference in the cost of the ½-inch and the ⅝-inch pipe, and the water delivered through a ⅝-inch is much much more than that delivered through a ½-inch pipe. Our standard is a ⅝-inch. I want to congratulate Mr. Buchanan on the paper he has given and the charts he has prepared. Anyone who is familiar with that kind of work knows that it represents a large amount of work and study. I hope that this paper will find its way into print so that we will have it on record.

The Chairman: Mr. Buchanan spoke of the comparative cost of lead and copper pipe. We use 11-pound lead, and the cost of lead is 55 cents as compared with 29 cents for copper pipe, and if you buy in large quantities you can get it for 27 cents.

Mr. Proctor's remarks bring to my mind the question of what is meant by per capita consumption. There is something there on which you may be led astray. I maintain that if you are going to figure the per capita consumption of any municipality, you should first take out your commercial and industrial water. You may have a municipality where the industrial water used in a very large amount. In my own town we used to think that our industrial works could maintain a population of 30,000 inhabitants, and we only had 8000 and were depending on outside places for our labor.

E. M. Proctor: That is very well illustrated in New Toronto. They have a separate system for pumping water to the Goodyear plant. Their per capita consumption is quite low, because the water taken by the Goodyear plant is not included.

T. Hodkinson: You have to take the operators who are employed in the industrial plants into consideration.

G. R. Jack: In East York we get our water from Scarboro. At the present time we have only one factory using water. Up to two years ago, when we started putting in sewers, our per capita water consumption was about 16 gallons per head. After we put in the sewers it jumped to 25 gallons per head. We are still constructing sewers.

M. Pequegnat: I very much appreciate Mr. Buchanan's paper for the reason that our conditions in Kitchener are similar to those at London. Their rates are slightly lower than ours, but they put in the service and we do not. With us the consumer pays for the service right from the main. We charge him a flat rate of $19 for putting in the service, whether it is on the far side or the near side of the street.

Concerning consumption: In the year 1924, our consumption was down to 52 gallons. Last year, 1925, the factories were working more and our consumption jumped to 65, but the consumption for domestic use both years was 22. The whole difference was due to the increase in industrial activities. For the last four or five years we have had these figures, and they do not vary 1 per cent on domestic consumption.

N. M. R. Wilson: Did I understand Mr. Buchanan to say that they do not meter their fire service? I have several cases where meters have been put on the fire service, and they showed that there is a considerable consumption in that way.

The Chairman: Personally I would not allow any person to have a 6-inch service unless I knew what they were doing. I do not think it is possible to have a fire service that will stand dormant for a long time and then come into use suddenly. I will tell you an instance of where we put a fire-service meter on a plant that was newly constructed, and the first quarter they used 232,000 cubic feet through their fire-service meter. It happened not very long ago that they had a bill for $162 for water passing through the fire meter, and we discovered that a paving contractor had attached his hose to their hydrant and used their water while he was paving the street.

Personally I think the size of the service is rather a local condition. There is one viewpoint that has not been mentioned, and

that is the loss you have through brass fixtures. Members of the section who have the Water Works Manual will find a very interesting topic on loss through stops. First the main stops, the curb stops, and then the cellar stops. I have had occasion to make some tests on stops, and I found the loss equal to 30 per cent. Many of you know the old waste stops that the plumber makes on the basement wall, and these cause a great loss of water.

H. F. Huy: The question of a $\frac{1}{2}$-inch service has been discussed. Changes in modern plumbing have brought it about that instead of putting in the type of closets that have been used so long, they are now getting a flush closet that will conform more or less to water works practice. I think in the past where we have been putting in $\frac{1}{2}$-inch service to the ordinary one and two-family house, they should be changed to $\frac{3}{4}$-inch service. When we do that, we find we have very little trouble in the house. It has been my habit in the past to get paid for every bit of water that leaves the pumping station. We are now getting paid for 98 per cent of the water that leaves our station. The only way we have accomplished that is by careful maintenance and by metering everybody. Originally we only got paid for 45 per cent of the water at our station. We have large manufacturing plants that have six and seven miles of pipe. There is no way of checking where the superintenent will take water. Sometimes they will go up to the top of the building and run in a pipe there. We place a meter on these fire lines and we keep a record of the consumption. In nearly all our fire connections of that kind, we take a tap off immediately beyond the fire meter, and we show them that in order to keep that meter in working order that is desirable.

Keith Webster: Mr. Pratt said that we had not much of a water works system in Owen Sound. I would like to say as a commissioner of Owen Sound, and as a resident there, that we have quite a water works system. We have a gravity system and there is no pumping to do. We supply water as cheaply, if not more cheaply, than any other municipality in the province. We supply house service at 25 cents a month. If there is a bath in the house, that is \$1.00 a year extra, and if there is a water closet, that is \$2 a year extra. That makes \$1.50 a quarter, payable in advance.

Our water works system cost $400,000, and it will belong to the water-takers when paid for. The city has never levied a dollar upon the tax-payers.

We have made provision for interest and sinking fund. The water runs down-hill. Our intake comes in at about 240 feet above the level of the town, and is carried to a reservoir that is 200 feet above the level of the town, and that gives us all the pressure we require. Our superintendent, Mr. Pratt, is not only employed in connection with the water works. He does not give the water works all his time. The city council pay part of his salary for being plumbing inspector, and he gets another allowance as building inspector.

We have over 40 miles of main on our streets and 165 hydrants. We are following the system of having valves in front of each hydrant.

Our idea is to give such a low water rate that everybody will want to take water. We charge the city $20 for each hydrant, and we charge them for flushing the streets, and so on. Our profit last year, after everything was met, was $3500. It would cost about $12,000 to meter our system, and we think that it is better to let the people waste a little water than to go to the expense of putting in meters.

The Chairman: I think you are very fortunate in Owen Sound.

E. V. Buchanan: If some one will move that the banquet will be abandoned to-night, I will proceed to answer all your questions. If any of you are commissioners, and you want to be re-elected, I would advise you to leave the water rates alone.

You cannot make a comparison of water rates in different cities without first knowing the source of supply, because if you have water that runs right into your pipes, you do not have expensive pumping. Then again, you must consider whether the mains are paid for out of local improvement plan or by the municipalities. Then you must take into consideration whether the municipality pays for fire service, watering streets, and so on. There are fine points that have to be considered before you can make a comparison.

It is a very difficult matter to justify a service charge to the consumer. He thinks that when he has paid for the water going through his meters, he has paid for all he should pay. My own idea of a service charge is that first of all you should put all the fixed charges on that portion of the plant which is specifically for the use of the

consumer—the meter in the cellar, the stop-cock service, the distribution mains, and if you add all these charges together it will figure about \$8 a year. Our service charge is only \$6 a year. Anyone who pays less than \$8 is getting service below cost, and someone else must be paying for it. I cannot get it into my head that a service charge is not correct.

Someone has asked as to the life of a meter. I think it is about twenty or twenty-five years. Of course, it all depends upon the condition of the water.

Mr. Keith asked as to water rates in London. They are \$11 a year, and we do not think that is an exorbitant charge. People on a flat-rate, with a large house, who have a small consumption, secured a lower rate when the meters were put on, and in some of the smaller houses with a larger consumption the rates were raised.

In reference to the per capita consumption, the figure 1 produced shows that it works out at about 17 or 18 gallons per capita for domestic use as against a total per capita consumption of about 65 gallons last year.

A 16 per cent increase in our pressure produced a 25 per cent increase in consumption.

It is a little hard in London to justify the cost of meters against the saving at the present time. It cost about \$175,000 to meter the system. It would cost about \$150,000 to secure the water to supply the saving that we made. But in addition to the cost of getting the water, you have the cost of pumping and delivering it.

The day is not far off when the city of London and a great many other cities will have to enter upon a very extensive scheme for securing more water, and if you can possibly postpone that by metering the system I think it is a good investment.

J. Clark Keith: In The Journal for January, 1926, the contribution by the late Leonard Metcalf is of much interest in relation to the paper just presented. Mr. Metcalf has listed 51 American cities, and divides them into five groups ranging from those with a population of less than 25,000 to those in excess of 1,000,000. In each of the five groups he has made a study of their water consumption over a period of twelve years, in which interval their metered services increased from 83 to 96 per cent. In each group, despite the increase in metering, the consumption increased from 67 to 90 gallons per capita. His figures show that increased population results in a definite in-

crease in the per capita use of water. This increase is about 10 per cent of the increase in population.

In other words, if the population of the community doubles, one may reasonably expect to find a 10 per cent increase in the per capita use of water.

It should be noted that this refers to cities which have at least 83 per cent of their service metered. Any water works superintendent in a growing community that is 83 per cent metered, who can keep his per capita use stationary or reduce it, is securing better than average results.

A measure more effective than metering in reducing waste lies in increasing water rates. The figures show that a 100 per cent increase in water rates reduces the consumption by 40 per cent. Such a procedure to curtail waste would not meet with the approval either of the executive heads of the department or of the consumers, as increased rates could only be justified when required to cover capital and operating costs.

It would not be fair to the other elements of a water works system to say that the house services are the most important unit, but they at least constitute the main source of revenue, and as such should receive special consideration.

The depth of house services is subject entirely to climatic conditions, ranging from 4 feet in the mildest sections of Canada to 9 feet in Northern Ontario and the Prairie Provinces. In the West they are frequently frozen at that depth, and it is not unusual to see the electric thawer at work in June caring for a service which the frost had just reached. The service should be laid in its entirety from the main cock to the stop and waste within the house by the water authority of the community. Any departure from or division of this work, even with close inspection, will prove unsatisfactory from the view point of the distributor.

For ordinary house services galvanized pipe should be placed in the same class as hoop skirts, while lead pipe at present-day prices bids fair to give way to copper.

It is difficult to make any arbitrary ruling with respect to the laying of services prior or subsequent to the laying of pavements. Where it is very evident that a street is to be built up immediately under conditions of growth such as exist in the Border Cities to-day, or where the nature of the development is pre-determined through property restrictions, it would be unwise to defer the laying of services until after the pavement is laid. It should be an axiom

that all services of this character be laid well in advance of the pavement, so that there will not be subsidence at a later date. Where the mains and services are laid as a local improvement, it does not impose as serious a burden on the property-owner, when spread over a period of years, as would be the case when laid as individual service with the resultant demand for payment of the entire sum. Each street should be considered independently, the judgment of the executive head to dictate the policy.

The use of water in the City of London compares favorably with that of any city in Ontario, and the amount of water unaccounted for comes well within the legitimate limit commonly set. From information contained in the paper it is difficult to determine just what the annual bill would be to an average householder and any estimate is open to correction. At 80 gallons per day per meter or 16 gallons per capita (5 to the household), this might approximate \$11.50 under the metered rate, compared with \$8.10 under the previous flat rate. This represents an increase of 40 per cent, which from the findings of Mr. Metcalf, should reduce the consumption by 22 per cent.

Where flat rates have prevailed in a community for some time, it is difficult to inaugurate a policy of general metering without some opposition. With a meter rate which is equitable, it is the general experience that the metered customer pays less for adequate service than his unmetered neighbor. There cannot be any reasonable argument against the metering of water any more than there would be against the use of gas or electric meters. While not in accordance with the recommendations of the American Water Works Association, there will be less opposition to a rate which includes a definite quantity of water with the minimum charge than if there is a service charge alone.

A study of water rates in the Province of Ontario shows that those of the privately operated system of the Walkerville Water Company at 10 cents per 1000 gallons for normal domestic use are as low as any. This company furnishes 80,000 gallons of water to a metered consumer for \$8 per year, which covers the service charges as well.

The City of Windsor now has the installation of meters under way, the rate as yet undetermined. In the cities of Ontario there is a very marked difference in the per capita use between those which have limited and unlimited sources of supply. The City of London, with its source of supply unlimited, has a consumption which places it definitely in the group with those whose supply is limited.

The general installation of meters is an indication that a municipality desires to reduce the consumption of water. While meters may receive the credit for the decrease when installed, there are other factors which should not be overlooked. Waste-water surveys will probably be undertaken at intervals, detector meters will be placed on mains at convenient locations, and more frequent inspections of house services between the main and the house will take place. All of these help the reputation of the meter in eliminating waste.

In the concluding paragraph of Mr. Buchanan's interesting paper, he makes a passing reference to the water supplies of Ancient Rome, and it is of interest to note that even then they were concerned with the question of water waste and illegal use. Frontinus, who was a water commissioner of Rome in 79 A.D., has left us a memorable work which has been translated into English by Clemens Herschel, the developer of the Venturi meter. We can say at least, that some progress has been made hydraulically since those days, even if there is little attempt at standardization. Frontinus computed discharge by cross-sectional area alone. He had no idea of the velocity of water either in open or closed pipes. The well-known formula, $v = \sqrt{2gh}$, was not known until 16 centuries had passed. A square foot of area, whether in a stream or conduit or composed of the sum total of 200 or more pipes discharging at different elevations, was considered the same in value.

From the cisterns or tanks which received the water from the various aqueducts entering the city, the water was distributed in lead pipes up to 27 inches in diameter, the joints of which were soldered with pure lead. From inscriptions on these pipes, much of the work was done by female plumbers, but it is not recorded whether the female plumber of those days was any more efficient than the male plumber of today. They had their four-way branches, brass stopcocks, wiped joints, bronze bath tubs, and devices for measuring water in a crude way. A flat sheet of lead just under 4 inches long was rolled into a cylinder and this became the standard orifice measurement. On the end of this the water user was compelled to have a length of pipe 50 feet long of the same diameter. He could then expand it or do as he pleased. Evidently Frontinus had some idea of the friction loss in pipes, and to prevent these from becoming plugged, small traps were provided at intervals to catch the pebbles which came through the aqueducts. In many cases these orifices were made larger than the amount set forth in the grant from Caesar, and after systematically checking all water uses, Frontinus states that the finding of the sources of illegal use practically doubled the quantity available and was equivalent to finding new sources of supply. Thus may he be considered one of the pioneers in the attempt to reduce water waste.

THE POLLUTION OF WATER SUPPLIES BY WASTES FROM CANNERIES AND DAIRIES IN IOWA[1]

By J. H. Buchanan[2]

During the past few years there has been a very noticeable and steady increase in the output of Iowa canneries and creameries. This has been due in part to the construction and operation of new plants and in part to the enlargement of already existing factories. This increase in output has meant, of course, a considerable increase in the manufacturing waste, of which proper disposal should be made.

In normal seasons, and with the smaller manufacturing plants in operation, the problem of stream pollution has not seemed to be very serious. But with the centralization that is taking place, particularly in the corn canning industry, and in the dairies, the problem has become more serious. Particularly has this been true during the season that has just passed, when the water supplies of the streams had just been diminished to a considerable degree. In the past season there have been instances in which the streams into which our factory wastes have been discharged, have not carried sufficient water to furnish the proper dilution. In other words, the subsequent purification of this water for domestic use would be increasingly difficult, to say nothing about the nuisance that would develop.

Stream pollution is important to those interested in water supplies because of the difficulties arising in the purification of water from streams into which these trade wastes have been emptied. Corn cannery and creamery wastes differ from domestic sewage in that they contain undesirable amounts of carbohydrate, which in fermentation markedly increase the acidity of streams into which they are discharged. This acidity may be such as to render the water corrosive to water mains.

In order to emphasize this matter, two typical sets of analyses

[1] Presented before the Iowa Section meeting December 3, 1925.

[2] Associate Professor of Sanitary Chemistry, Iowa State College, Ames, Iowa.

will be considered. Table 1 shows the effect of corn cannery waste on the stream into which this waste was discharged. The samples analyzed were as follows:

1. Composite sample of the waste collected hourly during a day's run of the plant.

TABLE 1

Effect of corn cannery wastes on stream

Results expressed in parts per millon

	COMPOSITE SAMPLE	CREEK BELOW PLANT OUTLET	CREEK ABOVE PLANT OUTLET
Solids:			
Total	1860	860	528
Dissolved	1600	820	480
Suspended	260	40	48*
Nitrogen:			
Ammonia	1.5	0.85	0.025
Organic nitrogen	28.5	11.15	1.00
Oxygen consumed:			
Total	746	145	51
Dissolved	490	142	48
Suspended	256	3	3
H+ ion concentration (pH):			
Initial	7.7†	5.6	7.4
After 2 days	5.1		7.5
Biochemical oxygen demand:			
3 days	320	250	42
5 days	515	370	60‡

* Sample collected when water was low. There was evidence of mud contamination.

† Reaction after boiling. Before heating value was 6.6.

‡ Estimated from three day result.

2. Water from the stream above the outlet of the plant waste.

3. Water from the creek taken one-half mile below the outlet of the plant waste.

While the results from these analyses would indicate that the stream was polluted before the factory waste was admitted, the possibility of contamination while taking the sample must be considered. The admittance of small amounts of bottom mud into

the sample accounts for the high oxygen consumed and oxygen demand values of the stream water.

An inspection of table 1 brings out the fact that the stream has been seriously polluted with factory waste. The total solids of the plant waste are about 3.5 times that of the stream before pollution. An increase of 332 parts per million is noted at the point where the sample was taken below the plant outlet. It is also interesting to note that the increase in total solids in the stream water is due almost entirely to dissolved solids. This indicates of course that the suspended solids had been removed by settling in the half mile interval between the plant outlet and the point at which the sample was taken. This waste from the corn cannery would tend, therefore, to produce unsightly deposits, and furthermore would be subject to fermentation with the production of acid and disagreeable odors.

A study of the nitrogen values also shows the extent to which pollution occurred. An appreciable increase is noted in the stream water below the outlet, both with regard to the free ammonia and total organic nitrogen. A dilution not to exceed 1 to 4 is indicated, which dilution must be considered inadequate. In this calculation no account is taken of the chemical changes that may have taken place between the outlet of the plant and the point where the sample was secured.

The values for oxygen consumed indicate a waste about ten times as strong as domestic sewage. The high value for the suspended material brings out the same point mentioned with regard to the solids, that a great deal of good would be accomplished by removing the suspended solids. This determination, essentially a measure of the carbonaceous material present, shows the large amount of organic matter present that would be subject to fermentation.

The biochemical oxygen demand may be employed as a measure of the oxygen required to prevent the decomposition of sewage with the production of objectionable odors. Stream water ordinarily carries from five to eight parts per million of free oxygen. The high oxygen demand of the sample below the outlet points to the fact that there would be a definite depletion of the oxygen in the stream. This would result not only in the production of objectionable odors, but also in death of the wild life of the stream.

The acid production in the plant waste is a measure of the fermentation that is taking place. The sample of waste gave a pH value of 6.6. After boiling the value changed to 7.7 which indicates less

acidity due to the volatilization of acids formed in the fermentation. After two days of storage the boiled sample, inoculated with Bact. coli, developed acidity to the extent of pH 5.1, or in other words, the sample had become one hundred times as acid. The fact that a pH of 7.4 was obtained on the creek water above the point of the plant outlet and that below this point a pH of 5.6 was obtained, shows that in spite of the dilution with creek water the acidity had been increased nearly one hundred times.

This increase in acidity would be of extreme importance when considering the stream as a source of water supply. The corrosive effects on the pipes with which the water would come in contact would be serious. There would be difficulties in purification of the water due to the increased hydrogen ion concentration. This would be particularly true where some of the chemical methods of purification were used, because of the fact that this acidity would need to be neutralized before the process of purification would function properly.

In considering stream pollution due to creamery wastes no table of actual analyses will be given. An examination of a number of composite samples of creamery waste, collected every 30 minutes for an entire day's run, showed that they contained sufficient milk to correspond to from 1 to 5 per cent skim milk, with an average strength equivalent to about 1.5 per cent skim milk. The average Iowa creamery waste would show the following analysis:

	p.p.m.
Organic nitrogen	35–45
Oxygen consumed	600–750
Biochemical oxygen demand	750–900

It is evident that a considerable load would be placed on a stream attempting to care for a creamery waste, figured on the basis of 1.5 per cent skim milk. Creamery wastes, as those from corn canneries, contain undesirable amounts of sugar and will quickly sour, increasing the acidity of the streams into which they are discharged. Ordinarily in problems of stream pollution the interest lies in the question of oxygen depletion, but, with the wastes in question, the effect on the acidity of the stream is of particular interest to the water works operator.

SUPPLY, INTAKES AND STORAGE[1]

By William Gore[2]

In the Manual of Water Works Practice recently issued by the American Water Works Association, the first six chapters deal in an excellent way with the subject of this paper. It is not the intention of the author to attempt to summarize the matter contained in these chapters, but rather to place before you the result of his thirty-five years' practical experience in all phases relating to water supply and sewage-disposal, and the bearing the one has on the other on the selection of a suitable source of water supply for any community. While the laws of nature are the same in all parts of the world, the climatic and physical conditions and the governing laws are different, so that here in Ontario we must of necessity have our own particular method of approaching the problem, and this is the reason that this article is not a summary of the Manual, but rather the result of personal experience.

All water used for public service earlier or later is derived from the clouds by precipitation as rain or in frozen form principally as snow. This precipitation varies from place to place and from time to time in any one locality so that its incidence is a problem in each situation (of climatic conditions and probabilities) based on the assumption that its variations in the past will continue into the future. Many observers have endeavored to discover cycles of change in periods of years, and cycles within cycles over centuries, but after all it may be stated authoritatively in this regard that the day that is past never returns again, so that we may regard the incidence of rainfall and the flow of a water-course, a spring or a well resulting therefrom, as one of pure chance, with limitations. Not that we regard the world as being governed by chance, but that the factors that enter into this problem are so numerous and varied in their amplitudes that they become too intricate for normal evaluation and recourse must be had to statistical probabilities.

[1] Presented before the Canadian Section meeting, March 3. 1926.

[2] Consulting Engineer, Toronto, Canada.

NATURAL STORAGE OF WATER

The water that is not lost by evaporation or absorption by percolation is collected into streams or rivers. It may be stored for use in reservoirs or lakes and in the crevices of rocks and soils and then be made available for use either directly by gravity or by pumping with or without the expedient of sinking wells and adits driven into the water-bearing rocks. Thus we have two great divisions in the sources of water-surface supplies and underground supplies.

In the Province of Ontario at the end of 1924 there were 205 municipally owned systems of water supply and 8 privately owned systems. Surface supplies numbered 133 and underground supplies 76, while combined or unknown sources of supply numbered 4, so that the number of surface supplies are almost double those from underground sources. The total amount of water derived from surface supplies forms the bulk of the whole, and is therefore far and away the more important. The dependence of water supplies upon rainfall is somewhat marked in the neighborhood of the Great Lakes System which stores up vast quantities of water which are discharged from the outlets of the lakes at a nearly uniform rate, the minimum flow at any time being hundreds of times greater than the needs of the population along the shores, and this source is therefore almost unlimited.

Where the dimensions of the stream get less and less in relation to the population depending upon it for water, some estimate has to be made of the amount that is or can be made available at all times from it. Obviously the period to consider is that in which the flow of the stream is at a minimum. This occurs in times of drought when the weather is dry and warm, and when the demand for water is greatest. Frost may also cause the streams to dry up, particularly when they are either small or in a northern district, and the demand at this time may also increase because of the running of taps to avoid freezing.

A long period of continuous record of the flow of a stream is desirable in order to determine the amount of water that can be secured from it either directly by the daily records, or, if a reservoir is needed, to tide over the low flows and high demands by plotting mass curves.

STUDY OF RAINFALL STATISTICS

Generally speaking the stream records are not available and when this occurs a hypothetical mass curve must be prepared. This can

only be done after a very close study of the rainfall statistics of the district and stream flow statistics from other comparative sources. Such estimation must be regarded as the work of high specialization and cannot be gone into at length here, but a typical example is worked out and the general results are as follows:

1. Only a proportion of the rainfall is available as stream flow and this proportion varies over wide limits from place to place. The actual loss in this vicinity may be as much as 20 inches per annum reckoned over the whole drainage area.

2. The minimum flow of a stream may be nil and frequently less than 10 per cent of the average, and the maximum flow may be many times as great in the absence of lakes, reservoirs or vast areas of porous materials to modify the flows.

3. The effect of reservoir capacity in balancing the irregularities of supply and demand is most pronounced at small demands and reservoir capacities relative to the flow of the stream.

4. It is generally regarded in the typical case that not more than 80 per cent of the flow of a stream can be economically secured by the use of reservoirs upon it. This may be obtained when the storage amounts to about six months' supply. Such reservoirs are usually formed by constructing dams across the streams. These invariably form engineering works of the first magnitude and their development has taken place over a long period, occasionally attended with serious failures involving great destruction of life and property. Much thought and study have therefore been given to every phase of this problem, both from a practical and theoretical viewpoint. It may be said, however, that almost every failure has been due to a disregard of the practical requirements of the situation; that is to say, to attempted economy, incompetence and inexperience.

RIGHTS OF RIPARIAN OWNER

The right to take water from any stream for water supply purposes has not been well established in Ontario from the legal standpoint, owing, no doubt, to an abundance of water and the absence of powerful riparian owners interested in maintaining the flows of the streams unimpaired. The right of a riparian owner is that of a user only and is founded on the common law of England, briefly stated as follows:

Any unauthorized interference with or use of water to the prejudice of one entitled to its use is the subject of an action for damages.

He has the right to have it (the water) come to him in its natural state in flow, quantity and quality and to go from him without obstruction.

Thus to divert water from its natural source can only be legally met by compensating in some form or other the riparian owner. The demands of a municipality are of course insistent and the riparian owner must make way for such diversions. His interests have usually in Great Britain been met by securing for him a fixed proportion of the flow of the stream augmented in dry periods from water stored in reservoirs built by the diverting authority.

In any actual stream of water there is an inevitable mixture of surface and underground waters, because all drainage areas have a proportion of porous materials thereon into which the precipitation penetrates, some portion being returned to the atmosphere and other portions given out as springs which feed the stream at times when the rain ceases. The water that enters into the porous materials dissolves them and so alters to a considerable extent the character of the water. It may be hardened by calcium and magnesium compounds, which up to a limit is desirable. It is found that about 60 parts per million of hardening constituents are desirable in a domestic water. The water may be stained by juices primarily of organic origin and also become acid so as to attack lead service pipes. It may collect iron and manganese. These features are objectionable, and if considerable, the water will require special treatment by purification processes.

Most watershed and gathering grounds are subject to the possibility of contamination by animals and human beings as well as by developed industries. The Public Health Act, 1914, gives the Provincial Board of Health of Ontario full power to protect the source of any public water supply within its jurisdiction and a penalty of $100 may be incurred for each offence. The exercise of this power to the full would have introduced serious difficulties of an economic nature, particularly along the Great Lakes System, where much of the contamination comes from sources outside the province and a considerable degree of toleration has been permitted. In order to meet this situation, water has been and is being used for domestic purposes which contains a degree of pollution, and it becomes a matter of grave consideration as to how much pollution can be allowed in the source of a water supply without endangering the health or outraging the tastes of the community. This, of course,

depends upon the purification processes available for treating the water before it reaches the consumer.

POLLUTION IN GREAT LAKES SYSTEM

The International Joint Commission on the Pollution of Boundary Waters has stated that the limit which purification processes can meet with boundary waters is reached when B. coli are positive in 50 per cent of the 0.1 cc. samples carried out over a period of at least a year.

This standard has been accepted with certain reservations in the Manual of Water Works Practice.

It has been shown that in the Great Lakes System there are practically no points at which water can be secured free from pollution. In a general way this pollution hugs the shore in the neighborhood of the cities, it being blown hither and thither, becoming more diluted as time proceeds, and by natural processes the pollution ultimately becomes dissipated. This of course applies to all waters in contact with the atmosphere, from which the necessary oxygen is obtained for this process described as self-purification. In the meantime there is the possibility of considerable intermittent pollution at any water works intake in the vicinity due to these wind-driven currents, which require constant vigilance on the part of the water-purification authorities.

A municipal authority is responsible legally in the case of negligence, and morally at all times, for the quality of the water delivered to its people.

Very serious situations have arisen owing to specially objectionable matter gaining access to the water supply, and which is made evident by the formation (with the chlorine used as a sterilizing agent) of chlorophenols and chlorocresols or other products giving the water objectionable tastes and odors. This is a matter which is having the attention of the health authorities, and the practical solution for overcoming these tastes is close at hand. Tastes and odors in water may also be derived from decaying vegetation and algae growths requiring treatment by copper sulphate or by aeration as well as by the usual filtration and chlorination processes.

During the break-up of the winter conditions and prolonged wind storms, most streams and lake fronts used as water supplies are subject to considerable turbidities as well as pollution, and these produce difficulties in the supply of a pure and sparkling water which

can only be dealt with by purification plants of sufficient capacity to meet the situation.

SITES FOR INTAKES

The sites for intakes in the waters or rivers or lakes demand much care in their selection in order to avoid as much as possible transient pollutions or turbidities which hug the shores, bottoms and surfaces. The intake mouths must be so large that the intake velocities are small, and of such form as to avoid vortices which may draw in air or ice. To avoid the latter, large covers are sometimes placed over upturned wide bell mouths with entirely satisfactory results. The intake in a river should not introduce large disturbances in the current, which would cause erosions, nor tend to the formation of frazil ice, nor should they obstruct shipping unless permanent structures are provided, manned and controlled like a lighthouse. These are expensive to maintain and absolute isolation is occasioned at times. Many instances are on record of intake pipes being broken on the occasion of wind storms, so that it becomes desirable where possible to drive intakes at a low level or in such strata that their safety is definitely secured. Where this is not possible or desirable, considerable protection can be secured by sheet piling, but any interference with the natural underwater surfaces produces a chain of indirect changes difficult to follow or to provide for.

WATER FROM UNDERGROUND SOURCES

These are derived from springs, driven wells, adits, collecting galleries and bore holes. These waters differ from surface waters generally in their considerable content of dissolved mineral matters and their freedom from pollution or turbidity. Thus the principal treatment to make these waters potable is their demineralization by means of softening, rather than the removal of disease germs. But experience has shown that these underground waters are peculiarly susceptible to contamination on exposure, and the records show dire results from neglecting the necessary precautions. Disease germs have been known to travel underground for miles and cause infectious diseases afterwards. However, springs and wells from time immemorial have been regarded as among man's greatest blessings and are likewise so regarded by Scriptural precept, and it is little wonder, for in the semi-arid regions where the Scriptures were written the very life of the people and their flocks were dependent upon

such wells. Springs or wells of water are in our own civilization looked on with favor for direct drinking, owing to their palatability, sparkling clarity and coolness.

In certain other cases medicinal properties have been discovered, and mineral baths are prescribed for certain ailments. We have even at this age our sacred pools where cures are frequently recorded. Such waters may have been locked up for ages in the interstices of the rocks and have become highly mineralized and very seldom come within the province of the water works engineer. They are small in quantity, but exceedingly important in the Spas and Bads of the ancient world. Waters containing sulphuretted hydrogen or iron carbonate are specially sought after. The one as an aperient and the other a tonic.

Any public authority depending upon underground sources must have reasonable assurance of the quantity available, as determined by gauging in the case of a spring, and from the rainfall and percolating area and pumping records in the case of a well, and even then a well is a precarious undertaking, and many have been the disappointments both as to quantity and quality, but in spite of these the public generally believe there are great quantities of untapped suitable water available. Perhaps the experience at London, England, accounts for this belief, as there many millions of gallons of water are daily delivered to the city from such sources, but the situation is exceptional, and even here the saturation level has been falling for many years about 1 foot per annum, showing that the stock is being absorbed, not an unusual experience with well waters.

Such is the precarious nature in most places depending upon a run for fortuitous circumstances, that well-sinking should not be resorted to for a public water supply unless a satisfactory surface supply is not available. Spring flows are exceedingly variable and may dry up altogether either by a deficiency of rainfall or another outlet being found. The spring, however, can be dealt with by gaugings and statistical probabilities and can be considerably augmented by reservoirs, which should be covered to prevent algoid growths, to which these waters are peculiarly susceptible.

Most driven wells depend upon the fortuitous circumstance of striking a faulting plane or back or crevice, as the movement of water in so-called water-bearing rocks is generally exceedingly slow. In some of the important wells there are many miles of collecting galleries which have struck a crevice here or there and generally the supply has come partly from stock.

Underground waters may be found in sands and gravels, in sandstones and limestones and to a less extent in other materials. The limestones are specially interesting in this respect as they are soluble in rain water, which becomes hardened thereby, and large underground rivers and caverns are formed, like the system of the Kentucky caves. Such caves and underground water courses are truly wonderful, but the searching for the latter amidst the caves may not be rewarded.

Sometimes a well, after yielding good water for many years, has suddenly become brackish. The explanation afforded is that the well was dependent for many years partly upon the surface percolation and partly from sea water or from deep-seated salt water which has been satisfactorily treated by means of the natural zeolites in the bedded materials. When these materials become used up, the well becomes brackish.

The movement of water in open sands and gravels is generally understood. The flow towards a well is dependent directly on the slope of the saturation surface and the area of flow, and inversely as the specific surface area of the materials. The surface of saturation in the vicinity of a well in sand being pumped is approximately a logarithmic surface of revolution but is usually described as a cone of depression. This cone of depression in open materials has been observed to extend to great distances. Where such does take place, one well affects the yield of another. The common law gives no protection whatever, and instances have been noted where well sinking has proceeded in two wells by two authorities, one against the other. Instances are known where a well is so free that tidal phenomena has been observed in it.

Water supplies have been sought by excavating large so-called filtering basins in the sands and gravels by the side of large bodies of water. These often at the beginning have a good yield, which gradually falls owing partly to depletion of stock and partly to the pores of the source becoming choked.

Sometimes water-bearing strata are shut down underneath impervious materials which themselves are depressed below the surface levels of the water-bearing materials at some more or less distant point. Boreholes sunk through the impervious materials in the depression to the water-bearing materials will enable the water to flow freely to the surface, and such wells are called artesian.

The subject of this paper has been treated in a very general way,

with the object of bringing out the main underlying features that are considered essential in the selection of a suitable source for a water supply. No attempt has been made to enter into construction details, particularly such details as are connected with intake works. Each source of supply has to be considered on its merits.

When I went into your excellent exhibition room, my attention was drawn to a pamphlet on the cover of which was written, "What is water?" The professor under whom I was taught chemistry was a great authority on matters of chemistry, and he always used to write it down H_2O+, although he recognized that the chemical formula was two atoms of hydrogen and one of oxygen. Yet all the water we had to deal with contained other substances; if it had not these other substances in it, it was no good to use. So we are dealing with H_2O+. Mr. Brown in opening the meeting said he regards water as a commodity. I do not. He talks of water as so much material sold for cents. In my view of it the cents are for service. It is the cost of the service—taking water from one spot and pumping it up by pressure, and delivering it through pipes to a certain place.

The ownership in water is that of user only, not an exclusive ownership. That is the reason there is so much trouble about Chicago. The people of Chicago have acted as if they owned that water. They do not own the water. Their right is just that of user, and they have to use it so that anyone else having certain rights in it will not be injured. The whole world has certain rights in it.

If we had to depend on the gaugings of streams to tell how much water might be obtained, at least 90 per cent of our water works would never have been constructed. When an engineer goes on the job he has to plan his water works not within a certain period of years, but then and there. He cannot wait to set gauges for himself to run over a period to twenty or thirty years, and he must of necessity use rainfall as a basis.

There is no order about rainfall. It is pure chance. There may be dry years and wet years, but you cannot take seven wet years and say they will be followed by seven dry years and thus get an average in fourteen years. It takes say one hundred years to get a true average with a high probability of covering all variations likely to occur. Stream records and rainfall records are a problem, and chance, but as a rule the theoretical chance fits the fact, and this chart shows definitely that it is a pure chance beyond all question. The

rain gauges, together with the experience we have had with other water works shows how to deal with the problem satisfactorily.

Here is a slide showing the intakes in the Detroit River and vicinity. The little village of Tecumseh takes its water from Lake St. Clair. Highland Park, near the center of Detroit, in which is situated the Ford Works, gets its water out in the lake, and pumps it to a reservoir and filtration plant. Detroit has its intake in the river at the head of Belle Isle. Detroit is now putting in a new supply. Their present supply has a maximum of 320,000,000 U.S. gallons, and they are putting in another intake to increase that supply to 500,000,000.

Next comes the intake of the Border Essex Utilities Commission. Then a little lower down Mr. Brown gets his supply for the town of Walkerville, and a little lower still is the Windsor intake. The Essex Border Utilities Commission has constructed a sewer to collect a large portion of the sewage and discharge it into the river below the intake of the Water Commission. On the Detroit side I do not think they have a sewage-purification plant of any sort. Their sewage is discharged into the river and flotsam is often observed from the sewage discharge from the Detroit plant coming right across the river. Water supplies in the vicinity of a river like that can only be obtained by going up the river above the point of serious contamination.

DISCUSSION

T. J. Lafreniere: I wish to congratulate Mr. Gore on his very able survey of the various sources of water supply. There is one point that I would like to stress, and it is the necessity for water to contain something besides H_2O. I have in mind the case of one town which is using a very poor water supply. This water contains practically no coloring, and a very small amount of organic matter. The alkalinity runs around six parts per million. This water, as you can see, is almost distilled water, yet the steel pipe which is used to bring the water to city has been very badly corroded. This is a nasty situation, because the town is claiming damages from the contractor. I would like to ask Mr. Gore if he has had any cases of corrosion where the water is pure, chemically speaking.

R. O. Wynne-Roberts: We have listened to a very excellent paper and it will be of great value to us.

As Mr. Gore admits, it is a general discussion on the subject, and therefore does not raise many points of controversy.

No community can exist without water, hence it is that in arid countries, springs and wells and seasonal streams are regarded with almost religious reveration. It needs but a visit to such a district to appreciate the value of a spring of cool water, and the great difference in the social life between places which depend upon distilled water like Aden, and Toronto, which enjoys the bountiful supply from the Great Lakes. Between these limits there are countless examples of water supplies both visible and underground.

Whilst it is acknowledged by us that water supplies are derived from rainfall, it is interesting to hear some people insist that some underground supplies are fed from the lakes, notwithstanding that during the past ages the lake bottoms have been made practically impervious by deposits of comminuted material.

Visible water supplies, such as from streams and springs, are always attractive sources, and with careful conservation they are satisfactory within the limits of their capacity, and subject to preservation from contamination. Self-purification of streams and lakes is a matter which requires much consideration. Polluted waters pouring over the Niagara Falls do not become self-purified until diffused in the lake below.

The building up of mass curves to ascertain the yield from streams and the storage required to equalize the flow, can be depended upon in proportion to the accuracy of the data available. But to depend on such curves to estimate by analogy what may be the yield of a neighboring stream, is a method to be applied with great discrimination.

In the absence of authentic records of stream flows and rainfall on a particular catchment area, the engineer is obliged to adopt analogy as a means of computing the estimated yield. Formulae to ascertain the approximate run-off will often serve as a guide. The yield during driest years must fundamentally be the basis of estimated supply, and whilst there are no periodical recurrences of similar meteorological conditions, it is necessary to study the record very carefully.

In the St. Catharines district the three driest years on record may be 1870–1–2, when the average rainfall was about 30 inches per year. The next three driest years were 1905–6–7, when the average was 32.2 inches per annum; and the mean of all years is about 35 inches.

Mr. Gore estimates that about 20 inches of rainfall is lost by evaporation, floods and so on. This is presumed to be the mean, and if so, in dry years it will be more. So in this district the yield per square mile will be less than 400,000 gallons per day, assuming that ample storage is provided. The popular conception that a forest induces rainfall is not proven by records, but forests, however, are great conservers of water.

The color of water is important if only from a sentimental viewpoint. Capetown water has a deep brown tint, which stains baths, etc.

With regard to underground water, it may be said that in many localities it is the only available source. The location of wells is often by no means a simple matter, but it is possible by persistent exploration to strike water-bearing strata. Even in districts where the geology is fairly well known, the drilling for good water is often a perplexing matter, and in complex glacial deposits the problem is more involved. But by careful study of the substrata and of the records of any existing wells it is possible to simplify the exploration for water.

The question of how much water it is possible to obtain from wells is another problem which involves much investigation.

Incidentally it is useful to consider the many opportunities for developing our knowledge of underground strata, through the organized preservation of the logs of drilled wells. These exist in a few districts where wells have not been sunk, but the recording of the data thus obtained is generally lost. A step was taken two years ago by the Ontario Government to have all such information recorded in the official archives for future reference, and to enable the geologists and others to build up reliable cross-sections of the country, but the Legislature would not sanction such a step.

Mr. Gore's paper certainly affords abundant scope for discussion as to future elaboration of information for the use of engineers and the public in general.

E. V. Buchanan: I was very much pleased with Mr. Gore's very able paper. I contend that Mr. Gore wrongly condemns an underground supply.

Mr. Gore: I did not condemn any underground supplies.

E. V. Buchanan: In London we have had an underground supply for about fifty years, and I know the trials and tribulations an engineer has to go through in finding a further source of that kind. Running a water works department is not altogether engineering, it is partly political. If people have been used to drinking cool and sparkling waters, and if there is a river running by their doors that stinks to high heaven, and if you tell them you are going to give them river water, the engineer will lose his job.

The problem as we see it in London is this: At the present time we have a sufficient underground supply. We can get other underground supplies that will enable us to supply the city for a number of years to come, and so long as the total cost of developing this supply is less than the annual interest charges on the lake supply which would have to be piped for 45 miles, nothing is being lost and everything is being gained by using underground water.

The problem of knowing where to drill wells is a difficult one. Mr. Wynne-Roberts has said that it is a pity that logs are not kept of wells. Such information would be very useful. We have gone through the country talking to farmers and well-drillers, but we have been unable in that way to obtain approximate data regarding wells in all places, but we have tabulated information obtained and taken levels which have produced very interesting information and have enabled us to obtain further sources of supply.

Mr. Gore: Mr. Buchanan must have misunderstood my remarks. In any case the getting of water supply is a question of expediency. It would hardly be possible for me to think that because the water flows on the surface in a sewer that it is more suitable than a spring of clear, pure water. No, I do not regard it in that way. In fact I ought to say that the low flows of a stream are spring water. There is no river that has not spring water in it. What I wish to demonstrate is that in searching for underground waters by means of wells or borings you are dealing largely with an unknown quantity, and if you have two sources equally suitable, measure them up in what way you like, using every factor, even the political if you like, and then, if you have two sources equally satisfactory, I would choose the surface one, because then you know what you are getting and in an underground source you do not.

These works have to be designed beforehand. You have to go to your cities and see where you can get a supply. Even if it is the

digging of a well, every engineer who has had experience in well-digging knows the uncertainty. I know cities that under the advice of their engineers have sunk wells and have had to abandon them. There are very few cases that I do know of where you have the rain gauges and the stream that you cannot tell beforehand that there is a supply, if the quality is satisfactory.

E. V. Buchanan: During seventeen years of weekly tests from the wells at London, they have never shown any trace of colon bacilli.

Mr. Gore: That is one of the excellent qualities of underground supplies. They are usually pure and palatable. Even in my own household I use well water because I like it for drinking. I have had to go to all sources I could get, and I found it exceedingly difficult to get information as to an underground supply. It has been said that well-diggers should supply the Government with the information, but if you go to the owner of a well and ask for the information, he will say: "Bill So-and-so has the information," and you go to Bill and he will say that the Government has the information. You go to the Government and they say, "No, Bill has the information, and we will make him supply it." But I find that I cannot get the information, although I want it.

The question of water attacking steel is a very difficult problem. I remember the case of the Coolgardie water line, which was 350 odd miles long, and was used to supply water for the Coolgardie gold-mine district. That pipe showed serious corrosion. Sir Wm. Ramsay and my own firm were called on to investigate the cause. The chemists were not able to say why that particular water had extreme corrosive influences. One chemist suspected the presence of carbon-dioxide in abundance. They tested it and found it normal.

It may be that pH enters into it. This investigation did show that oxygen was the main factor as a depolarizing agent in the presence of electric current and deoxygenating the water was advised, but not accepted.

Three grains of calcium carbonate per gallon were added to the water but the corrosion continued as before. But since I have been in Canada I have read an article saying that the deoxygenizing process had been in operation for some years with marked success.

It is believed that hard water deposits a film of calcium carbonate

on the plates, which acts as an obliterating agent by which the water cannot get through to the pipes. This question of corrosion is a big matter.

I would like to say that water is very unique in nature. There are many gasses and solids, but there is practically only one fluid. The chairman says that anyone would prefer a gallon of water to a gallon of alcohol. I certainly vote for the gallon of water.

R. H. Starr: Do you not think that now would be a good time for the Canadian Section of the American Water Works Association to put themselves on record as being in favor of reforestation? Not on the small scale that is being carried on. If we cut down an acre of forest, it surely ought to be replaced by more than an acre to take care of our increase in population. If we could take care of reforestation we could take care of our rainfall in the spring, and get a more uniform stream flow and a more uniform water supply.

The Chairman: That matter will be referred to the committee on resolutions. I am sure you gentlemen have all been intensely interested in Mr. Gore's paper and the discussion which has taken place and the explanations which he has made.

IMPROVEMENTS TO THE WATER SUPPLY OF WINNER, SOUTH DAKOTA[1]

By Geo. T. Prince[2]

The city of Winner, South Dakota, is located in a district in which it is difficult to obtain water in large amounts sufficient for public water supplies. Such water as is obtainable is to be found underground. The sub-soil generally is of a very fine sandy nature that makes it difficult to obtain the water because of the packing and encrusting nature of the fine sand sub-soil about the strainers employed with the tubular wells.

The city has in the past been depending upon water for its public needs obtained principally from two 24-inch Kelly wells sunk to a depth of about 28 feet and reinforced by about 15 wells of 6-inch tubular type that were sunk approximately 28 feet. All of these wells are connected to an 8-inch water main that was laid at a depth of approximately 8 feet below the surface of the ground.

This well system is located about 8½ miles south of Winner on ground about 80 feet above the elevation of two circular concrete reservoirs that are located about one mile south of the center of the town, and that afford a static pressure in the business section of about 60 pounds per square inch. The connecting pipe between the reservoirs and the aforesaid well system is an 8-inch machine banded wooden pipe.

There are no authentic records indicating the amount of water used in Winner, which has a population of approximately 2500. The nearest estimate would indicate from 100,000 to 125,000 gallons per 24 hours. This amount of water has had to be pumped in recent years from the two 24-inch Kelly wells, the fifteen smaller tubular wells having Cook strainers have not afforded any water, as the sand bed from which the water is obtained is very fine, the coarsest being about like granulated sugar. This sand has become encased around the screens to such an extent that the tubular wells have practically been useless for some years.

[1]Presented before the Iowa Section meeting, November 8, 1924.
[2]Consulting Engineer, Omaha, Nebraska.

Because of a shortage of water the city authorities employed a number of engineers to submit reports upon ways and means to increase the amount of water for public purposes. The speaker submitted tentative plans for obtaining the desired additional water supply, which were finally adopted and approved by the Council. A contract was effected between the city and an Omaha contracting firm based upon the following plan of procedure:

It was believed that the fineness of the sand subsoil precluded the use of open jointed or perforated underground pipe lines or even cribbing. In place of employing such a type of construction, it was decided to adopt that of an open trench which was to be excavated across the draw in which the aforesaid wells were located. This draw is about 500 feet in width and experience indicates that a large portion of the drainage from 20 square miles located above and to the south of the said system of wells passes as under-flow below the draw in which the wells are located and about 15 to 25 feet below the ground level.

The adopted plans considered excavating a trench across this draw having a width of 6 feet inside and a depth of about 15 feet below ground level. The said trench was to be sheathed with 4-inch thickness of sheathing plank that was made by nailing together two 2-inch planks, the planks being so lapped as to leave at least 6 inches. The two planks thus nailed together for their entire length with their 6-inch lap formed a couple, and contiguous couples on either side made it possible to make tight work, each couple lapping the companion by 6 inches. These planks nailed together in couples were first sunk by water jet to the required depth. The sheathing forming the upper or south line of trench was sunk to a depth of 18 feet below ground level or 3 feet below the bottom of the trench when excavated. Those forming the lower or north side of the trench were sunk approximately 22 feet below ground level or about 7 feet below the bottom of the trench as excavated, thus forming a submerged timber cut-off against the passage of water.

The trench was afterwards excavated as stated to a depth of about 15 feet below ground level, the sides of the trench being firmly braced by longitudinal and transverse members as the excavation proceeded, said bracing being spaced from 3 to 4 feet apart vertically.

The purpose of making this trench 6 feet in width was primarily to make it possible to sink Kelly wells to a depth below the bottom

of the trench should it develop that such a measure would be necessary to secure the desired amount of water.

The sheathing planks at the east end of the trench for a distance of 10 feet were sunk to a depth of 24 feet below ground level. The reason for sinking the plank sheathing deeper at the east end was to provide a sand pocket into which sand that might be held in suspension in the water would be deposited before entering the outlet pipe, which is connected with said sand pocket at an elevation approximately 15 feet below ground level.

The tops of all sheathing plank were sunk to a depth of 2 feet below ground level and furnish a support upon which was placed a 6-inch steel reinforced concrete cover that extends for the full length and width of the collecting gallery. The gallery is 300 feet long.

Five manholes have been constructed of concrete which extend above the concrete cover to ground level upon which iron frames and covers have been placed to afford means of entering the gallery should occasion require for inspection and possible removal of sand.

Over the concrete slab there has been placed earth filling to an elevation slightly above ground level to allow for settling. This earth filling has a 6-inch topping of black soil and will be seeded so that the gallery will be covered by grass sod and present a smooth surface with the surrounding field.

The water level in the gallery when no water is being drawn stands approximately 4 feet below ground level. It is believed that the sheathing plank will last indefinitely under these damp conditions. If in years to come, however, it is necessary to replace the tops of said plank sheathing, this can be done at small expense.

The water level with the gallery in service is drawn down about 4 to 5 feet. This collecting gallery will afford an ample supply for the needs of the city for some years in the future. The city is not using the amount that the gallery will afford, which at present is approximately 300 gallons per minute.

In order to deliver the water from the gallery at a depth of 15 feet below ground level, it was necessary to lay 2500 feet of 10-inch cast iron pipe connecting with the existing 8-inch machine banded wood pipe, whereby it is possible now for the city to dispense entirely with pumping its water supply, the water being delivered by gravity into two concrete circular reservoirs, each having a capacity of approximately 80,000 gallons.

Such in brief is a description of the methods adopted to obtain the required additional water supply. The cost for the 300 feet of collecting gallery complete was $11,500.

WATER PURIFICATION FOR SMALL CITIES[1]

By H. V. Pedersen[2]

Is it practical for a city, as small as 1000 population, so unfavorably located as not to be able to secure a sufficient quantity of safe and palatable water for public use from wells, to consider the installation of a purification plant and develop a surface water supply? Anyone answering this question definitely, either negatively or affirmatively, might be accused of rather hasty decision as one answer might be just as incorrect as the other. The correct answer as applied to a particular community depends largely upon local conditions, and should not be made until all of the determining factors have been carefully studied. But I shall go as far as to say that, when a small city has become thoroughly dissatisfied with its old well supply, and determines on a change, the development of a surface supply should in all cases at least be considered.

Every city regardless of its size should choose or develop the safest, most palatable, and most practical water supply for public use that it can. Some few cities in Iowa are so favorably located that they have no problem whatever in securing an excellent public water supply. Nature provided an abundance of clear safe water within easy reach, and the city officials of the past only needed to dig a well, install a pump and pay the power bills to fulfill the duties of their offices. It was so easy that it required no thinking, and it cost so little that the general public came to take it all for granted.

Many other cities, however, have not been so favorably located. Nature was not so kind to them, and they have been compelled to spend large sums of money developing a well water supply. Although the State as a whole has been blessed with an abundance of underground water, there are sections where this water cannot be considered a satisfactory public supply, because of the mineral content and objectionable tastes. Many of the shallow water bearing sands are loaded with iron, and many of these sands lying beneath

[1] Presented before the Iowa Section meeting, November 7, 1924.

[2] Sanitary Engineer, State Board of Health, Des Moines, Iowa.

or adjacent to a city or town do not produce a bacteriologically safe water supply at the present time.

The northern half of the State is generally thought of as having an inexhaustible supply of unquestionably safe underground water. There is no question but that there is a large quantity of water, but it is amazing how rapidly this water is diminishing. Just what may be the cause of the lowering of the water table is difficult to say, but we are inclined to believe that it is due to the fact that the underground water is being used up in a wasteful manner faster than it can be replaced.

The greater part of the northern half of the State is underlaid with a limestone formation. A well drilled into this formation years ago was rarely cased below the stone. Many cracks and crevices have gradually opened, and enlarged, due to erosion and exposure, allowing unpurified surface water to pass for long distances and contaminate a vein of water that has furnished the public water supply. The majority of these deep wells produce a very hard water. Some of the waters are so hard and so full of iron, carbon dioxide, and other corrosive agents, that the life of the best well casing is not over twenty years. Thus it is that many deep wells which were once perfectly safe, now produce a water which is contaminated, and rendered unsafe from sources that are beyond human control.

Some Iowa towns have been trying for years to develop a satisfactory well water supply. In the southern part of the State some cities have not been able to locate an adequate well supply, and have therefore simply done without a public water system. Three cities within the last year located in the southern half of the State installed water purification plants as a result of long years of waiting. In a northern part of the State many towns have been getting along as best they could on a hard disagreeable-tasting water for they believed there was nothing that could be done or that there was no way to obtain a more palatable water supply. Several cities within the last year have installed softening and iron removal plants, which have proved satisfactory. The great majority of the towns, however, have continued to use a hard unpalatable, unsafe and an altogether unsatisfactory well supply because they are under the impression that it is impractical or impossible for them to consider the development of a surface supply, or do anything to improve their well supply.

For the benefit of those small cities in the State so located that they cannot secure a good underground water supply, I am going

to relate the experiences of several cities, that have taken place within the last few years.

The city of Adel, with a population of about 1500, did its best for years to put up with a shallow well water that contained a great deal of iron, was hard, and had a disagreeable taste. Finally the public refused to stand it any longer, and the council decided to make every effort to secure a more satisfactory supply. All of the available underground supplies in the near vicinity were located and tested with little success. After a careful search a good shallow water-bearing sand was located about $1\frac{3}{4}$ miles from the city, which furnished an excellent water. After the council had deliberated and carefully considered the advisability of treating the water in the original old well, and the development of the new shallow well proposition, it finally decided to construct a small rapid sand filter plant and purify the water from the Raccoon River, on whose banks the city is located.

A contract was entered into, and as a result the city now has a 120,000 gallons per day purification plant. The water is first pumped from the river to a small aërator, from which it flows by gravity into a coagulation basin 9 feet wide, 32 feet long and 12 feet deep, where the water is treated with alum and allowed to settle. From the coagulation or settling tank the water flows by gravity through a sand filter 5 feet wide and 8 feet long, to a clear well. This clear well has a capacity of about 4000 gallons. From the clear well the water is pumped into the distribution system which includes a storage or pressure tank. Liquid chlorine is injected into the water at the intake of the high duty pump to insure sterilization.

The question might be raised as to the wisdom on the part of the city in installing the above plant in preference to developing the shallow water-bearing sands located $1\frac{3}{4}$ miles distant. It cannot be denied, however, that a fine filter plant was secured at a total cost of about $11,000 complete, including a chlorinator. As it was estimated that it would cost in the neighborhood of $25,000 to develop the shallow well, it is evident that the city made a considerable saving as far as first cost was concerned. Viewed from the eyes of the public the city council secured a good filter plant capable of furnishing a comparatively soft, clear, safe water for public use at a saving of $12,000 or more and it is satisfied.

The city of Sigourney, like Adel, also had its past troubles, but its experiences were of an entirely different nature. On the advice of some local genius a council some years ago carried a water main 5

miles distant to a small river where a natural purification plant was to be developed. The attempt to develop a natural filter was a complete failure, due entirely to improper advice and design. As no other supply was available, and as the resources of the town had been completely drained, the city had to put up for years with the very unsatisfactory, dirty, raw river water that could not be used for drinking or culinary purposes.

Finally a city council determined to secure a better water supply. They brought in a number of consulting engineers to advise them. Three out of four engineers advised the council to install a modern rapid sand filtering plant, on the ground that the deep well water would contain a great deal of objectionable mineral salts which would cause a taste. No amount of advice could impress the council, or overcome the memories of the past sad experiences, and a contract for a deep drilled well was let. The deep well, drilled within the city limits, a pump house, and pumping equipment was installed for approximately $30,000. As predicted, the water from this well is very hard, and contains such an amount of mineral salts, that it cannot be considered satisfactory for drinking purposes. The public is dissatisfied with the result and prefers to use private, shallow, contaminated wells in preference to the public supply.

The city of Adel might have been able to develop a good shallow well supply, but they chose to treat or purify a surface water which in this case was the cheaper method. Sigourney might have developed an excellent surface water, but chose to develop the hard impalatable deep water at great expense, because they believed a surface water could not be purified to be fit for drinking purposes no matter what it might cost.

The chief argument which discourages the development of a surface water supply, is the operation. No one can deny that a water purification plant must be given careful, intelligent attention, or it will prove a failure. I do wish to emphasize, however, that a small city need not think that it must necessarily employ a high priced engineer to operate a water purification plant. A conscientious, industrious, intelligent man may be placed in charge, and taught in an amazingly short time all there is to know. In the small city a plant may need to be operated only half of the day. The operator might therefore be a commissioner of streets, or be given some similar office, whose duties can work in well with his duties as operator. It is evident that the larger the plant the more time is required for

operation, and naturally the various problems increase in magnitude, but the point is that a good intelligent local man, if he is the right man, can be developed into a competent operator in a surprisingly short time, if given an opportunity. No small city need continue to be without a public water supply, or use a bad well water for fear that they could not find a man to operate a purification plant in a successful manner, provided they are willing to pay a fair salary.

The question of cost of operation also enters into the problem of deciding whether the development of a surface supply is practical. Much can be said on the subject. It is no doubt true that it would cost more to operate a purification plant in some places than it would to operate a well supply. Every water works system no matter how simple it is must have some sort of caretaker in charge. The majority of the public water systems of Iowa have a caretaker who devotes from one to twenty-four hours per day. It is not necessary to increase the number of men to take care of the average small city purification plant. The same intelligent caretaker who can take care of a well system, could with a little more time take care of a properly designed purification plant. At Adel the operator spends about one-half of his time at the plant, the rest of the time he is taking care of extensions or acting as assistant street commissioner. Although the cost of operating a purification plant, therefore, is greater than that of a well system, it cannot be said that the cost is excessive or prohibitive.

It has been definitely proven in other states, as well as in our own, that the purification of a surface water supply is practical. I wish to go on record for believing that, when a city of 1000 population and upward is dissatisfied with its public water supply, it should at least consider the development of a surface supply before it spends a great deal of money in developing or adding to an already unsatisfactory supply.

PERMANENT STANDARDS FOR WATER ANALYSIS

By F. R. Georgia[1]

Many colorimetric methods are employed in the analysis of water. In certain of these methods more or less permanent standards of comparison may be prepared and used.

These standards are frequently kept in stoppered Nessler tubes or in bottles from which they must be transferred to tubes for use. In any case the standard solutions are exposed to evaporation and probable contamination every time they are used.

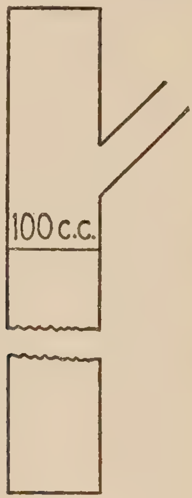


Fig. 1

In order to eliminate these objections the tube shown in figure I was designed. This tube is the same size as a 100-cc. Nessler tube, but is closed at both ends and the ends are polished. A side arm is provided for filling the tube. After filling to the graduation on the tube the side arm is closed off. A series of tubes is prepared to cover the range desired. The standard solution in such a tube is protected

[1] Department of Chemistry, Cornell University, Ithaca, N. Y.

from external contamination since it is not opened for use. The only contamination that can take place is such as might result from the glass of the tube itself.

If one looks down through a tube of this sort the eye focuses on the upper end of the tube rendering it difficult to make a comparison with the usual tube that is open at the top. In order to get rid of this difficulty a colorimeter of the Woulff type was rebuilt so that it would handle these tubes and the usual 100-cc. Nessler tubes. In using a colorimeter the eye is focussed on the prism of the instrument and one is not conscious of whether the observation tubes are closed at the top or not. With this instrument comparisons with standards in the tubes above described are as easily made as with other tubes.

Since the tubes are not completely filled some of the vapor from the solution in them may condense and form drops on the tops of the tubes. These drops may be removed by inverting the tubes momentarily.

Tubes of this type are a great convenience in colorimetric determinations where the standards are reasonably permanent.

DISCUSSION

SPECIFICATIONS FOR COLD WATER METERS

The following information is the result of a conference between W. W. Brush, Deputy Chief Engineer of the Department of Water Supply, City of New York, and Chairman of the New England Water Works Association's Committee on Standard Specifications for Water Meters; C. M. Saville, Chief Engineer of the Hartford Water Works and Chairman of the American Water Works Association's Committee on the same subject; S. M. Van Loan, Deputy Chief of the Bureau of Water, Philadelphia and a member of the American Water Works Association's Committee; R. K. Blanchard, Chairman of the Meter Manufacturers Committee on Specifications; and the undersigned. The conference was called to interpret certain paragraphs of the specifications for cold water meters.

The Standard Specifications for Cold Water Meters, adopted by the Water Works Associations, does not provide for any tolerance. It is, therefore, impossible to expect the specifications to be complied with exactly in so far as they stipulate dimensions or their equivalents. Practically this has not been found to be of any consequence, since all of the meter manufacturers are working in accordance with the specifications and no difficulty has thus far resulted.

The following comments are submitted.

External bolts. The sentence "Nuts shall be designed for easy removal after having been long in service" means that provision shall be made either by the use of different metals or compositions, or possibly in the form of the threads so as to avoid nuts and bolts rusting together and preventing the easy removal of the nuts. Practically, it generally means the use of a composition nut at least or the avoidance of the use of steel nuts and steel bolts.

Registers. No particular difficulty has been experienced from the failure to stipulate minimum capacities of registers and maximum indications of initial dial in gallons as well as in cubic feet. Practically, it would be interpreted that the maximum indication of the initial dial corresponding to 1 cubic foot would be 10 gallons; to 10 cubic feet 100 gallons; and so on. Similarly for maximum register

capacities, where 100,000 cubic feet is stipulated, one million gallons would be taken for registers in gallons.

Connections for $\frac{5}{8}$-, $\frac{3}{4}$- and $\frac{1}{4}$-inch sizes. The gages referred to are the American Briggs which have been adopted by the American Society of Mechanical Engineers and the American Engineering Standards Committee. The Briggs standard gages are tapered, so that it did not appear necessary to say in the specifications that a tapered thread was to be used.

We understand that in practice the manufacturers have assumed that "within one thread of through the gage" means the minimum limit of size and that the specification was practically complied with if the gage could be screwed on to a point between three threads and one thread of through the gage.

In the case of the plug gages, we understand that the term "backed into the nuts" is a common shop phrase used by the manufacturers, intending to mean, screwed into the nuts, and that here again the manufacturers have assumed that the specifications would be practically complied with if the plug gage could be screwed into the nuts to a point between two threads of through the gage and flush.

Seal wire holes. There are not enough meters larger than 2 inch in size to warrant calling for drilling the nuts for seal wire holes for these sizes. Plants using water enough to require so large meters would almost invariably have mechanics who could arrange by-passes or some other means of stealing water, if they were so inclined, more easily than by shifting large meters. In these cases, sealing of register box so that the registration may not be tampered with appeared to be sufficient.

Measuring chambers. The word "sensitiveness" is intended to include accuracy as well. It is intended that the meter shall operate within the tolerances provided in later sections under any pressure up to 150 pounds. A meter is not considered to be "operating" unless it records the quantity of water passed within stipulated limits of accuracy.

Intermediate gear trains. It is equally important that bushings of any material should be so constructed that they cannot drop out.

Strainers. At least one meter manufacturer constructs meters of such design that the water passes through an annular space between the measuring chamber and the external case which is of such dimensions and form that it serves as a strainer, in which case, no strainer of the screen type is necessary.

Registration. It is satisfactory to have a meter tested under any working pressure up to 150 lb.

CHARLES W. SHERMAN,
Chairman, Joint Committee of American and New England Water Works Associations Upon Standard Specifications for Water Meters.

ABSTRACTS OF WATER WORKS LITERATURE

FRANK HANNAN

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

The Largest Artificial Reservoir. ANON. Eng. and Cont., **64**: 835–44, 1925. Description of the Queen Mary Reservoir which is to supply city of London, England.—*C. C. Ruchhoft.*

How Santa Barbara Water Works Went Through the Earthquake. ANON. Eng. and Cont., **64**: 824–25, 1925. Excerpts from bulletin issued by Allied Architects Association of Los Angeles containing reports and comments.—*C. C. Ruchhoft.*

A Little Known Fluid Principle and Its Practical Application. EUGENE F. DELERY. Eng. and Cont., **64**: 1043–49, 1925. Strainer system of New Orleans filters, which was designed to take advantage of velocity head, is described.—*C. C. Ruchhoft.*

Effect of Gravel Wall on Well Production. A. W. ROSS. Eng. and Cont., **64**: 1084–85, 1925. Dug well lined with steel caisson 28 feet in diameter and 32 feet deep had six 6-inch wells drilled in it to top of water bearing stratum, and only furnished 1100 gallons per minute. A 24-inch gravel wall type well was put down inside dug well to depth of 78 feet thereby increasing capacity of well to 2400 gallons per minute.—*C. C. Ruchhoft.*

Chicago Water Works Notes. ANON. Pub. Works, **56**: 443–44, 1925. Excerpts from report of Chicago Department of Public Works for 1924 on cutting large mains, use of leadite, pressure control, stopping underground leakage, fire hydrant damages, and chlorine booths.—*C. C. Ruchhoft.*

Tunneling for Sewers in St. Paul. GEORGE M. SHEPARD. Pub. Works, **56**: 433–37, 1925. Methods used in driving a 12-foot and an 8-foot tunnel are described.—*C. C. Ruchhoft.*

Prevention of Deposit in Water Mains. WILLIAM RANSON. Munic. and County Eng., **69**: 324–25, 1925. Deposits of iron formed chemically and by iron bacteria are discussed. Cement lining, or coating pipes with mixture of coal tar or pitch oils and rosin is recommended to prevent chemical incrustation. Efficient filtration with removal of organic matter will prevent development of iron bacteria.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Some Results of Pipe Cleaning. B. B. Hodgman. Jour. New Eng. Water Works Assoc., 39: 2, 171, June, 1925. Experiences over a period of twenty years in cleaning pipe mains.—*W. U. Gallaher.*

Iodine and Water Supplies. H. W. Clark. Jour. New Eng. Water Works Assoc., 39: 3, 204, September, 1925. Concise history of iodine-goiter situation. Concentration of iodine in Massachusetts water averages 2.14 p.p.b., varying from 0 to 6.3 p.p.b. Iodine deficiency may be overcome by using iodized table and food salt, and sea foods.—*W. U. Gallaher.*

The Water Works of Quebec City. J. A. Tremblay. Jour. New Eng. Water Works Assoc., 39: 3, 208, September, 1925. Development of Quebec water works is described. Present source of supply is the St. Charles River. Water flowing by gravity seven miles to city is delivered at pressure of 50 to 110 pounds per square inch.—*W. U. Gallaher.*

The Filtration Works of the City of Montreal. F. E. Field. Jour. New Eng. Water Works Assoc., 39: 3, 213, September, 1925. Montreal has 50 m.g.d. filtration plant, water first going through rapid sand, then through slow sand filters. There are sixteen of each type; former, having combined area of 19,200 square feet are washed with air and water; latter, having combined area of 256,000 square feet are washed by means of two Blaisdell machines. The filtered water reservoir has a capacity of $6\frac{1}{4}$ m.g. (Imp.). Plant is now working 20 per cent in excess of designed capacity. Bacterial efficiencies are as follows: pre-filters (rapid sand) from raw water—66 per cent; final filters (slow sand) from pre-filters, 89 per cent; from raw water, 95 per cent. Wash water used; on pre-filters, 0.39 per cent, on final filters, 0.09 per cent; total, 0.48 per cent. Total operating cost for Montreal plant is $2.50 per million gallons (U. S.). New 30 m.g.d. pumping station and new 20 mg. (Imp.) filtered water basin have been recently built. New 100 m.g.d. (Imp.) rapid sand filter plant is soon to be constructed.—*W. U. Gallaher.*

A Fineness Modulus for Filter Sands. R. G. Tyler. Jour. New Eng. Water Works Assoc., 39: 3, 239, September, 1925. Progress report on work to perfect a method for designating size of filter sands. Following conclusions are drawn: (1) surface modulus of a filter sand gives fair approximation of transmission capacities and head losses under varying conditions of discharge; (2) it gives more accurate results with sands tested than other methods now in use based upon mechanical analyses of materials; (3) a sand is defined more specifically by its surface modulus than by its effective size and uniformity coefficient; (4) the King aspirator is indicated as a most accurate instrument for predicting flow through sands. Ibid. 39: 4, 456, December, 1925. F. Hansen and G. F. Catlett. Discussion of above paper.—*W. U. Gallaher.*

Some Features of Filter Design. J. W. Armstrong. Jour. New Eng. Water Works Assoc., 39: 3, 254, September, 1925. Quickness of settling is increased in proportion to number of baffles in mixing basin. Placing of submerged cross baffles with parabolic shaped tops in coagulation basin causes

more uniform deposit of sludge. Concrete constructions must be impervious to water, especially in cold climates and where water is capable of dissolving calcium and aluminum compounds. Money can be saved by not building filters over filtered water reservoir and by using wood instead of concrete for elements continually submerged. The potentiometer may be used to determine the pH and to control accordingly the dosage of lime and, in some cases, of alum. Slat bottoms for filter beds are perhaps the most economical distributing systems. Filter sands should be uniform. A turbidimeter designed by Baylis which will read to within one-tenth of one part per million is illustrated and described. Turbidity in effluent at Baltimore plant is used instead of loss of head as key to washing filters.—*W. U. Gallaher.*

Lawrence, Mass., Water Supply—Investigations and Construction. M. Knowles, M. Mansfield, and P. Nugent. Jour. New Eng. Water Works Assoc., 39: 4, 345, December, 1925. Present water supply at Lawrence, the Merrimac River, is insufficient and also very unsatisfactory due to disagreeable tastes and odors. In 1916, money spent for spring water in city equalled more than half amount of revenue from water-rate payers. Development of new supply is being continually delayed. New three-quarter acre slow sand filter to temporarily augment present supply is being constructed and new low service pump is to be installed.—*W. U. Gallaher.*

The New Little Quittacas Intake at New Bedford, Mass. F. A. Barbour. Jour. New Eng. Water Works Assoc., 39: 4, 370, December, 1925. Detailed account of construction of 60-inch pre-cast concrete intake conduit 1300 feet long, also of intake tower and screens. Article is profusely illustrated and full of construction details and expedients.—*W. U. Gallaher.*

The New Sebago Lake Intake and Conduit of the Portland, Maine, Water District. L. Metcalf, H. U. Fuller., and C. B. Mitchell. Jour. New Eng. Water Works Assoc., 39: 4, 394, December, 1925. Construction of 54-inch intake, 1580 feet long, terminating in gate and screen house over vertical shaft descending to tunnel in rock. Tunnel is 60 inches in internal diameter, 2100 feet in length, and discharges into 54-inch reinforced concrete conduit 1900 feet in length connected to existing supply mains. Much of tunnelling was done under air pressure. Construction costs, details, and illustrations are numerous.—*W. U. Gallaher.*

The Coolgardie Pipe Line in Australia, and Measures Taken to Prevent Corrosion. F. F. Longley. Jour. New Eng. Water Works Assoc., 39: 4, 421, December, 1925. The Coolgardie pipe line put into use in 1902 is a lock-bar 30-inch steel pipe 350 miles long. Its carrying capacity was much reduced during first few years of use due to tuberculation. Corrosion also caused many perforations, the number per year increasing as time went on. Mill scale was found to have great influence on pitting, and failure of protective coating of coal-tar asphalt mixture, due partly to weather and soil, encouraged deterioration. Lime added at rate of 4 grains per Imp. gallon decreased carrying capacity of pipe so much that its use was discontinued. Deaëration of the water by

vacuum reduced oxygen content 90 per cent, but its effect on carrying capacity of pipe is indefinite, pipe delivery being constant for last few years. If pipe were new, effect of deaëration would be more pronounced. Pipe is being uncovered to avoid soil effects and policy of removing leaky sections, repairing them, and inserting them in place of others needing repair has been adopted.—*W. U. Gallaher.*

Substitution of Machinery for Hand Labor in Pipe Laying. S. H. TAYLOR. Jour. New Eng. Water Works Assoc., 39: 4, 445, December, 1925. Use of steam shovels with special appliances, gasoline driven air compressor for handling ledges and boulders, gasoline driven pumps for taking water from wet trenches, and two or three trucks with dump bodies, made possible reduction of crew to 15 or 20 men when laying pipe in long trenches. From 120 to 180 feet laid per day at cost of 26.34 dollars per foot. Method is not practical for short lines scattered over system on account of cost of moving apparatus long distances. Three men averaged one lead joint in one hour and forty minutes at total cost of 18.06 dollars while same three men averaged six to eight joints per hour with leadite at total cost of 4.42 dollars each joint.—*W. U. Gallaher.*

An Emergency Water Supply for Leominster, Mass. W. G. CLASSON and C. W. SHERMAN. Jour. New Eng. Water Works Assoc., 39: 4, 450, December, 1925. Reservoirs constituting city's supply became so low in December, 1924, that permission was received from State Commissioner of Health to take water from Smith Pond on Monoosnoc Brook. Pump was installed, water was treated with 0.74 p.p.m. chlorine and fed to city mains. Cost amounted to 196.91 dollars per million gallons. Idea was later conceived of filling Fall Brook high pressure system reservoir which was low, with water from distributing low pressure system reservoir, which was full and overflowing, by diverting through mains. Cost amounted to 40.49 dollars per million gallons.—*W. U. Gallaher.*

Flow of Fluids in Pipe Bends. J. EUSTICE. Water and Water Eng., 26: 270, July 21; 301, August 20; 362, September 20; 392, October 20; 432, November 20, 1924. As result of application of colored filaments to flow of water in glass tubes author states that increased resistance to flow in curved pipes is due to difference in pressure between outer and inner radius of bend caused by centrifugal force, hydraulic gradient from outer to inner walls of the curve being established. Water follows path of least resistance so as to form vortices. If straight length follows at outlet end of bend, vortices formed in bend persist for considerable distance along the straight. Hence, gaugings taken along to a bend are not reliable, and investigators who have not recognized this have sometimes obtained results for resistance of bends which are misleading. Results of the author's experiments on resistance in wrought iron elbows, screwed over pipes, and wrought iron bends, from 0.2 to 2 inches in diameter are summarized and empirical formulae given. Results are also given of experimental researches on "skin" pressure exerted on pipe by water flowing through a bend. Experiments show that skin pressure at outer radius increases gradually to maximum at or near centre of right-angled bend, while a

somewhat similar gradual decrease occurs at inner radius. Experiments were made to determine the resistance in coiled pipes and through bends in series; and to determine the differences in pressure at different points of an elbow. References are given to papers on this subject by other investigators. Illus.—*Geo. C. Bunker.*

A New Deep Well Pumping Installation, Tunbridge Wells Corporation Waterworks. W. H. Maxwell. Water and Water Eng., **26**: 427, November 20, 1924. Detailed description of lining of two borewells of 38¾ inches in diameter at top and 336 feet deep and of pumping plant capable of delivering 74,830 gallons per hour. Illus.—*Geo. C. Bunker.*

The Employment of Storage Reservoirs in Irrigation, with Special Reference to the Krian, Perak, Irrigation Undertaking. F. W. Mager. Water and Water Eng., **26**: 435, November 20, 1924. Description of works for irrigation, for rice culture, of 42,000 acres of Krian district in state of Perak, Federated Malay States, largest irrigation work so far constructed in British Malaya. Abstract of paper communicated to Institution of Civil Engineers.—*Geo. C. Bunker.*

Water Power in the Netherlands East Indies. P. C. Coote. Water and Water Eng., **26**: 437, November 20, 1924. Data are given concerning sources of water power and the more important power stations in Java, Sumatra, Dutch Borneo, and Celebes.—*Geo. C. Bunker.*

Vegetable Decomposition in Ditch Water Simulating Sewage Contamination. L. Cobbett. Water and Water Eng., **26**: 445, November 20, 1924. Abstract from Jour. of Hygiene **22**: No. 4, July 1924. Late in autumn of 1922, following exceptionally dry period, water in some of ditches in low-lying land on west side of River Cam, where it flows past some of colleges from Queen's to St. John's, became foul, so that instead of looking dark and clear, as usual, it appeared milky, and gave off an offensive odor so like that of sewage that many people believed that it had become containated by leakage from sewer near by. This led to an investigation which proved that no pollution with sewage was taking place. On the other hand certain bacilli with single flagella were isolated from the water and found capable of giving off from their artificial cultures odor comparable to that of ditches. To these bacilli, acting on dead leaves in water, and probably in conjunction with other anaërobic bacteria generating hydrogen sulphide, sewage-like odor was attributed.—*Geo. C. Bunker.*

Ismailia Valves. Water and Water Eng., **26**: 447, November 20, 1926. So named because first installed at Ismailia Pumping Station, Cairo. It was designed to meet the conditions of pumping crude sewage and surface water, heavily charged with grit, sand, refuse, and solid matter, against a head of 300 feet. In practice, valve proved itself an unqualified success. It is a clear way valve without the disadvantage of a hinge, and is free to seat evenly like a disc pump valve; it works equally well whether placed horizontally or vertically and, owing to its simple construction, may be faced with any material to

suit nature of liquid pumped. Valve consists of two castings; accessories such as nuts, pins, washers, and screw threads are eliminated. Illus.—*Geo. C. Bunker.*

Standard Tests for Hydraulic Power Plants. Water and Water Eng., **26**: 151, April 22, 1924. Report of joint committee of Institutions of Civil and Mechanical Engineers. In appendix (page 144) are given systems generally used for determining volume of flow when direct volumetric measurement by means of measuring basin is not feasible: viz., venturi meter; pitot tube; weirs; current meters; salt solution method; floats; and travelling screen.—*Geo. C. Bunker.*

Bristol Waterworks: Cheddar Supply. A. M. Paterson. Water and Water Eng., **26**: 268, July 21, 1924. Cheddar supply is a standby and comprises following works: intake on stream at Cheddar; 33-inch cast iron gravity main from intake to pump station; pumping main, 9½ miles long, of which 7½ miles is 33-inch and remainder, 24-inch cast iron pipe; 500,000-gallon service reservoir near summit of pipe line; drainage and sewerage works at Cheddar. Steam excavator was used for cutting pipe trench, excepting where rock was met; under best conditions it cut 440 yards of 33-inch pipe trench in 49-hour week; its normal rate of travel was 6 to 7 yards per hour. Average total cost of excavation was approximately 3s. 3d. per cubic yard, with labor at 1s. 7d. per hour, and plant bought when prices were a maximum. Cost of hand excavation would have been 5s. Over 75 per cent of joints were caulked by pneumatic caulkers operated by petrol-driven air compressor. Lead was used, 2⅜ inches deep in 33-inch pipe joints. Jointers worked in pairs and 2 men would set up joint in 15 minutes. Backfiller was petrol-driven machine which dragged the material into trench by scoop working on drag line. Cost of refilling 33-inch pipe trench by its means was 4s. to 4s. 6d. per linear yard, little, if any, saving over hand labor. Pumping plant consists of 3 independent sets of high speed centrifugal pumps driven through intermediary of toothed helical gearing by solid injection crude oil engines. Each unit is rated at 1400 g.p.m. against total head of 306 feet. Engines are of Ruston-Hornsby two-cylinder horizontal type, built for working load of 234 b.h.p. Pumps are Mather and Platt 8-inch split casing 5-stage centrifugals, designed to run at speed of 1000 r.p.m. Conditions under which plant will operate initially are materially different from those which will ultimately obtain. Present working head with 3 pumps running is about 261 feet. By throttling discharge valves head was increased to 303 feet and pump discharge of 1680 g.p.m. obtained. Oil consumption per brake h.p. hour under these conditions was 0.44 pound, or 0.62 pound per horsepower delivered to main with brake h.p. of 220. Tests were also made at reduced speed, delivery valves being wide open; with the 3 units running together oil consumption was 0.42 pound per brake h.p. hour, or 0.59 per pump h.p. hour, at an average of 170 brake h.p. per unit and pump efficiency of 73 per cent.—*Geo. C. Bunker.*

South Staffordshire Waterworks. Water and Water Eng., 26: 271, July 21, 1924. From a brochure prepared by Fred J. Dixon, Chief Engineer. South

Staffordshire Waterworks Co. was established in 1853. Statutory district of supply extends into counties of Worcester, Warwick, Stafford and Derby, having collective area of some 297 square miles. Geologically, area supplied is composed of aqueous and stratified rocks formed during four different geological periods, viz., silurian, carboniferous, permian and triassic. Mean annual rainfall for 31 years period for company's area of supply is 24.33 inches. Bulk of water supplied is obtained from subterranean sources by means of deep wells, borings, and headings, and therefore has to be pumped to surface. There are 15 principal pumping stations, 7 secondary or repumping stations, and 18 impounding and service reservoirs. Owing to the undulating configuration of area of supply, distribution system is somewhat complicated. Sources of supply being nearly all on fringe of district, large and long pumping mains have been necessary. All the water has to be pumped; in 1923 total quantity pumped was 6,618,991,639 gallons; in addition 2,029,805,813 gallons were repumped to higher districts, some water having to be pumped 3 times. Average consumption per head per day in 1923 was; domestic 19.5 gallons; trade and other purposes, 4.2 gallons total 23.7 gallons. Total estimated population supplied with company's water on December 31, 1923, was 763,305, number of houses supplied being 152,661, and number of meters in use 4,341. Only water at present filtered is that from Brindley Bank boreholes. Mather and Platt's pressure filters, without coagulants, are used; solely for purpose of removing what are termed "iron bacteria." Brief descriptions of Wood Green, Slade Heath, Somerford, Pipe Hill, and Maple Brook pumping stations are given. Details are given concerning repairing, lining, and covering Shire Oak reservoir, capacity 4,250,000 gallons, constructed as an open reservoir during 1896–7. Floor consisted of mass concrete on gravel foundations; walls, also of mass concrete, having vertical water faces and being stepped on back. Floor and walls were faced with blue bricks. In January 1900, cracks which rendered reservoir useless developed in bottom, movement being due to subsidence consequent upon working of colliery at Walsall Wood.—*Geo. C. Bunker.*

Collapse of Perth, Western Australia, Filter Beds. Water and Water Eng., **25**: 291, July 21, 1924. Abstract from Commonwealth Engineer, April, 1924, pp. 373. Report, after Government inquiry, on collapse of north wall and conduit system of filter beds in connection with metropolitan water supply. Findings were (1) that failure was due to faulty design and construction, (2) that pillars supporting concrete conduit collapsing, the whole falling mass pulled down wall, (3) that if conduit system had not been attached to wall, and if wall had been reinforced, as in the design, failure would not have taken place. Chief engineer, owing to press of work, had not had time to inspect construction, which was regarded as of minor importance, and chief draughtsman had not in this case checked figures of his subordinates. Recommendations were that chief engineer should in future inspect all plans and drawings and give advice thereon.—*Geo. C. Bunker.*

Pumping from Wells and Boreholes. (The Application of the Turbine Pump.) F. Johnstone-Taylor. Water and Water Eng., **26**: 304, August 20, 1924.

At head of well is substantial frame. This serves two purposes: first, to support either a vertical electric motor for direct drive of pump, or if this is inadmissible, a gearbox for transmitting power from some other form of prime mover; second, to support from its base delivery pipe in well, which in turn supports pump, from which are hung suction pipe, foot-valve, and strainer. Inside delivery pipe or trunk tube is the vertical shaft. At rest, this shaft is entirely in tension; when running, tension is taken up by a thrust bearing, but the load thereon is somewhat balanced by hydraulic balance of pump, allowing shaft practically to float. Its steady running is ensured by lignum bushes, set in housings gripped between flanges of pipes. This arrangement permits accurate alignment of the lignum bearings which, running under water, cannot seize and require no lubrication. Mechanical construction thus permits of shaft of considerable length running at high speed without vibration, whole system from frame downwards being free to take up position of self-alignment. Apart from steam, not an economical proposition for small plants, and electric power, not always available, choice lies between gas and oil, necessitating gearing in either case. Diesel or semi-Diesel engine running on crude oil is likely to find greatest favor. Brief descriptions are given of installations at Ipswich, Doncaster waterworks, and Somerford pumping plant of South Staffordshire Waterworks Company.—*Geo. C. Bunker.*

Purification of Coke Quenching Water. Water and Water Eng., **26**: 381, September 20, 1924. Report on investigations into amount of poisonous matter discharged from coking ovens into River Marne states that analyses showed traces of phenol and notable quantities of hydrosulphuric and hydrocyanic acids, varying in accordance with place of origin of coal used, English coal being more sulphurous than that of the Sarre and the Ruhr. Existing purifying apparatus consisted of successive barriers of perforated planks placed across outfall ditch. Planks enclosed beds of coke and iron residue; water passing through these rough filters carried on surface traces of tar and naphthalene which were skimmed off now and then by hand. The filters retained about $\frac{2}{7}$ of acids contained in water. For remainder, Dr. Durand advised purification by means of strong solution of chloride of lime containing carbonate of soda. He gives following method for determining amount of concentrated Javel water required to purify 1 liter of water; place in saturation tube 200 cc. of water to settle, add 3 or 4 drops of sulphuric solution of indigo-carmine, and then drop by drop, by means of a Mohr burette, Javel water until blue color disappears; number of cubic centimeters used multiplied by 5 gives quantity of Javel water required to purify 1 liter. Purification of waste water is carried out in basins of known capacity communicating with works channel, dosage necessary being put into basin before water from channel is let in.—*Geo. C. Bunker.*

Use of Plastic Refractories in Boiler Furnaces. H. E. Weightman. Power, **63**: 3, 90, January 19, 1926. Some practical hints given. Discussion includes construction of walls, necessity of rigid foundations, construction of suspended parts, proper initial firing of plastic walls, control of the water smoking period, rules for cooling, characteristics of plastic refractories, modulus of rupture, testing the material, and cost consideration.—*Aug. G. Nolte.*

Effects of Changing the Load on a Synchronous Motor. J. M. CUNNINGHAM. Power, 63: 3, 99, January 19, 1926.—*Aug. G. Nolte.*

Handling Oil-Fired Water-Tube Boilers. G. H. BRIGGS. Power, 63: 4, 130, January 26, 1926. Proper regulation of air in operating oil-burning boilers is discussed.—*Aug. G. Nolte.*

Tendencies in Electric-Motor Control Installations. J. E. HOUSLEY. Power, 63: 4, 134, January 26, 1926. Attention is called to practices that should be avoided in controller installations and examples are given of methods for mounting motor-control apparatus that make for flexibility and safety in operation and maintenance. Illustrated.—*Aug. G. Nolte.*

Economical Coal Buying. H. B. STANTON. Power, 63: 4, 140, January 26, 1926. Author points out shortcomings of purchasing on heat unit basis and offers practical suggestions for selecting coal on performance basis.—*Aug. G. Nolte.*

Boiler-Water Conditioning with Special Reference to High Operating Pressure and Corrosion. R. E. HALL. Power, 63: 5, 194, February 2, 1926. Abstract of paper presented at Midwest Power Conference, Chicago, Ill., January 27, 1926. Summarizes the conclusion of four years research undertaken to establish essential conditions for prevention of adherent scale and corrosion. Definite relations have been established between boiler pressure, sulphate concentration, and carbonate concentration needed to prevent scale formation. These concentrations are measured by simple apparatus suitable for boiler room use. Other matters of interest touched upon are use of sodium phosphate in high pressure boilers, prevention of corrosion, and avoidance of excesses of CO_2 and other non-condensable gases.—*Aug. G. Nolte.*

Checking the Accuracy of Watt-Hour Meter Connections. W. F. WALSH. Power, 63: 6, 206, February 9, 1926. Some likely meter connection errors and methods of detecting these are pointed out. Illustrated by diagrams.—*Aug. G. Nolte.*

Draft of Chimney. J. G. MINGLE. Power, 63: 7, 247, February 16, 1926. Discusses fundamental draft equation of chimney design.—*Aug. G. Nolte.*

Stokers Pay Big Dividends in Heating Plant. Power, 63: 7, 253, February 16, 1926. In a relatively small plant containing three hand-fired return-tubular boilers which operate during heating season of seven months, installation of stokers saves more than $10,0000 over hand firing and use of oil for a short period. Saving effected during heating season of stoker operation over previous hand fired conditions amounted to 73 per cent of total investment in stokers and auxiliary equipment.—*Aug. G. Nolte.*

Eliminating Boiler Scale by the Agfil Process. D. A. GARDNER. Power, 63: 7, 261, February 16, 1926. In the past, power plant experts have warned

against presence of electric currents in boilers attributing pitting and corrosion thereto. Now, however, minute electric current passed over inside surface of boiler has been found to prevent adhesion of scale to metal and to remove any scale that may have been present before the application of current. Process was invented in Europe and has been in use there for over three years. Many successful installations are now in operation in power plants and tests in this country have shown method to be equally applicable to boiler conditions here. Apparatus consists of three pieces,—a thermopile, a vibrator and an ammeter. The thermopile is fastened to the steam main or breaching; one of the electrical terminals is connected to the upper boiler drum, the other, through a vibrator and an ammeter, to the blow-off pipe. Process is very much of a mystery and all attempts to explain it have been unsuccessful. Illustrated.—*Aug. G. Nolte.*

Furnace Designs for Coal and Wood Refuse. C. M. Garland. Power, **61**: 11, 406, March 17, 1925. Certain definite furnace designs for burning of moist or dry low grade fuels are illustrated and discussed.—*Aug. G. Nolte.*

Operation of Diesel Engines. R. Hildebrand. Power, **61**: 11, 414, March, 17, 1925. Successful operation depends to great extent upon combustion. Quality of fuel has a vital influence. Good combustion means quick burning of fuel at beginning of power stroke while poor combustion means slow burning extending over nearly the whole power stroke. Diesel engine can burn fuel oil varying greatly in character, but desirable grade should be used, even at greater cost. Fuel oil used in this country at present is generally "topped" crude oil, i.e., a crude from which higher oils, such as benzine, kerosine, gasoline, have been extracted by distilling. Unblended topped oil is called straight-run fuel oil. Compounded fuel oil is generally made up of heavy residues from refineries and bottom sediments from storage tanks blended with lighter oils in order to obtain a fuel with a desired specific gravity. Compounded oils are frequently unsuited for use as Diesel fuels on account of high residue content when heated. Analyses made of three fuel oils show considerable variation in residue. It appears that residue content and flash and burning points are not dependent upon specific gravity, or degrees Baumé. Tests show that a certain degree Baumé does not definitely indicate whether a fuel oil is suitable for Diesel Engine. While lighter oils do not contain as many heat units per gallon as do heavier, latter must be heated to prevent sluggish flow through pipes and atomizers. As a guide for buying fuel oil, author recommends following specifications;—Grade, straight run topped crude; Gravity, 20 to 30 degrees Baumé at 60 degrees F.; Heating value, 19,000 B.t.u., or higher; Flash Point, between 125 and 250 degrees F.; Burning Point, between 160 and 300 degrees F.; Residue, not over 10 per cent after sample has been heated in closed oven 120 hours at 575 degrees F.; Sulphur, not over 1.5 per cent; Water, not over 0.25 to 0.33 per cent; Ash, not over 0.10 per cent. Methods of heating fuel oil and injecting it into pump are discussed. Sulphur and other impurities chemically affect the engine. Water, dirt, and grit must be removed before oil enters engine. Filtering will eliminate many disturbances. Storage tanks should be cleaned occasionally but precautionary

measures must be taken to avoid explosions or asphyxiation. Tanks should be ventilated and no naked flames allowed to come near openings.—*Aug. G. Nolte.*

Will Sulphuric Acid Hurt an Oil Engine. A. B. Newell. Power, 61: 12, 454, March 24, 1925. For a number of years, burning of sulphurous fuel in oil engines has been known to do certain amount of damage, which often became manifest in form of pitted cylinders and valves. Sulphur in oil was blamed for this. Damage may be avoided at practically no expense while burning fuel of high sulphur content. Sulphur present in oil injected into cylinder burns without damaging engine and is converted into a gas which is harmless when hot and dry. Damage to engines has occurred after they were shut down and allowed to cool, thus causing sweating on interior surfaces. These small particles of water rapidly absorbed any sulphur present in gases left within cylinder and become dilute sulphuric acid which is very active on cast iron or steel. Since it is only necessary to have engine cleared of all sulphur fumes before it is shut down and allowed to cool, it is best, before shutting down, to switch onto some refined product such as kerosene which will contain no sulphur. Engine will be thoroughly purged of all foul gases in this way.—*Aug. G. Nolte.*

Feed Water Regulation. C. L. Hubbard. Power, 61: 12, 456, March 24, 1925. Radical changes in boiler design and operation require close feed water control. Water supply must closely follow steam demand through all load fluctuations. Character of load determines method of regulation to be used. Typical modern regulators are illustrated and described.—*Aug. G. Nolte.*

Modeling as an Aid in Power-Plant Piping Design. C. T. Van Dusen. Power, 63: 8, 282, February 23, 1926. Representing design by models is an aid in studying relation of various systems to one another and to other elements of plant. Such matters as ready access to valves, proper clearances for maintenance work, and neat and orderly appearance of piping as a whole are taken care of less satisfactorily by ordinary draughting room methods than by models. A special wax composition is used for modeling pipe. Copper wire used as core. Important decisions reached by discussing model rather than drawing.—*Aug. G. Nolte.*

How to Figure the Capacity of Chimneys. J. G. Mingle. Power, 63: 8, 288, February 23, 1926. Discusses factors determining area, or diameter, of chimney.—*Aug. G. Nolte.*

Questions and Answers. Franklin Van Winkle. Power. Subjects as follow: 63: 1, 38, January 5, 1926. Grooves in Engine Bearings; Steam-Pipe Coils for Heating Fuel Oil; Charging Refrigerating System with Ammonia; Effect of Altering Valve Setting. 63: 3, 112, January 19, 1926. Finding Boiler Heating Surface; Air Compression at High Altitudes; Pumps Short Strokes; Groaning Steam Valves. 63: 5, 192, February 2, 1926. Number of Phases in

a Wound Rotor for a Polyphase Induction Motor; Controlling Speed of Hydraulic Elevators; Grounding of Windings on the Rotor of Induction Motors; Dielectric Strength and Insulation Resistance. **61**: 11, 429, March 17, 1925. Hot-Water Supply to Outlet below Tank; Use for Oil Separator on Exhaust-Steam Heating System; Pounding of Simplex-Pump; Feed-Pipe Bushing; Increasing Back Pressure in Ammonia Refrigerating Plant; Unbalanced Area of Water Leg; Position of Crank at Half-Stroke of Piston. **61**: 12, 468, March 24, 1925. Thickness of Tube Sheets for H.R.T. Boilers; Centrifugal Force as Square of Velocity; Stiffness of Springs on Pump Valves; Discharge of Boiler Test Pump; Testing Leakage of Pump Valves; Source and Prevention of Clinker; Throttle Valves for Two-Cylinder Corliss Engine; Safe Pressure for Dished Heads; Relative Economy of Simple and Compound Corliss Engines. **63**: 8, 306, February 23, 1926. Starting a Centrifugal Pump; Figure Inside Area of Fire Tubes; Operating A. C. Motors in Parallel; Water Circulation on Hydraulic Elevators.—*Aug. G. Nolte.*

Present Status of Water Works Practice in Sweden. ALFRED JERDEN. Surveyor, **66**: 1702, 181, August 29, 1924. The population of Sweden (January, 1923) is 5,987,520; 1,813,177 living in the 111 cities and approximately 250,000 in towns of more than 1000 inhabitants. Eighty-five per cent of the cities, comprising 98 per cent of the total city population, have municipal water works, 95 per cent of the inhabitants of the various cities being supplied from this source. Ground water occurs relatively sparingly but there is an abundance of lakes and rivers. Per capita consumption is 17.6 Imp. gallons in metered cities and 26.4 in cities not metered.—*A. W. Blohm.* (*Courtesy U. S. Public Health Eng. Abst.*)

Rivers Pollution. C. JEPSON. Proc. Asso. of Managers of Sewage Disposal Works (England), 1923. Review of legal control over stream pollution exercised by government in England, and standards upon which such control is or should be based. First Rivers Pollution Act was passed in 1876, granting local authorities the power of taking action against persons polluting streams, but was a failure because the cities themselves were the chief offenders. Legal action for discharge of improperly treated trade wastes is usually slow and frequently hampered by saving clauses and restrictions that are taken advantage of by offenders. General rules should prohibit in trade wastes: (*a*) excessive suspended matter; (*b*) highly putrescible matter; (*c*) readily oxidizable matter (sulphides, etc.); (*d*) material acidity or alkalinity; and (*e*) sterilizing agents such as free chlorine. Suggested future requirements: (1) formation of additional rivers boards to be responsible for an entire watershed; (2) a central authority to assist rivers boards; (3) local authorities should provide sewers large enough to carry trade wastes, with power to assess special charges, if necessary; (4) manufacturers should have power to discharge waste liquors, after preliminary treatment, into municipal sewers without extra charge; (5) provision should be made to enforce and maintain satisfactory preliminary treatment of industrial wastes and prohibit discharge of wastes that interfere with sewage treatment processes; (6) creation of central research laboratory. —*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Bathing Places in New Jersey. Part II. I. R. RIKER and C. W. SPARMAKER. New Jersey Public Health News, 9: 12, 364, November, 1924. General discussion of swimming pool design and requirements. Features of recirculation and filtration systems, scum troughs and side walks, methods of disinfection, ventilation, light and heat, and accessories are discussed.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Ozonification of the Water of the River Neva. S. RASHKOVICH. Transactions of International Conference on Sanitary Engineering, London, 359, 1924. Detailed results are presented of experimental stations of the Technical Sanitary Institute of Petrograd. Most important factors in mixing of water and ozone are duration of contact, thorough mixing, volume of air used and concentration of ozone. To secure sterilization contact of ozone with the water should not be less than 10 to 15 minutes.—*A. W. Blohm.*

Supply of Drinking Water in the Dutch East Indies. JAN SMIT. Transactions International Conference on Sanitary Engineering, London, 356, 1924. Difficulties of supplying pure drinking water in the tropics are outlined. Gradual installation of central supplies has resulted in nearly 40 cities being served, at a cost of 20 million guilders.—*A. W. Blohm.*

London Water Supply Statistics, 1923–4. Surveyor, 66: 1712, 390, November 7, 1924. Daily average supply furnished was 248.87 m.g. in the direct area of supply and 2.06 million in bulk, a total of 250.93, the daily per capita supply being 36.16 gallons, an increase of 0.86 gallon over previous year.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Treatment of Moorland Surface Waters. LEWIS MITCHELL. Surveyor, 66: 1714, 423, November 21, 1924. Water supply of Bradford, Eng., is of excellent quality for domestic and trade purposes, but contains color derived from peaty gathering grounds. Scheme under consideration for removing color, consists of coagulation and sedimentation basins, rapid gravity or roughing pre-filters, and final treatment on existing slow sand filters at increased rate.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Bathing Places in New Jersey. Part III. Operation of Artificial Swimming Pools and Baths. I. R. RIKER and C. W. SPARMAKER. New Jersey Public Health News, 10: 3, 88, March, 1925. Article contains list of 34 outdoor and 82 indoor swimming pools with source of water supply, frequency of refilling and methods of purification and disinfection of water. Authors state "only six indoor pools and five outdoor pools contained water which would meet the tentative standard of the A. P. H. A. (Bathing Place Committee). The results which are greatly in excess of this standard are due in our opinion to a polluted water supply, faulty construction, poor operation, or inadequate sanitary supervision of bathers. We are satisfied that the tentative standard can be met in a properly designed and operated pool."—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

National Water Policy. Bradford Water Committee. LEWIS MITCHELL. Surveyor, 66: 1714, 422, November 21, 1924. Great need of conserving and utilizing to best advantage the comparatively few remaining unappropriated water supply areas in England is emphasized. It is suggested that every water authority should have a detailed program for 20 years in advance of requirements and general program of at least 50 years.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Aberdeen Water Supply. GEO. MITCHELL. Surveyor, 67: 1729, 280, March 6, 1925. Original plant, completed in 1866, consisted of a storage reservoir and 0.5 acre of slow sand filters, the latter subsequently increased to 2.5 acres. Plant enlarged in 1920 by 3 slow sand filters covering 1.4 acres, new intake, screening chamber, aqueduct and storage reservoir.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

The Effect on Canned Foods of Industrial Wastes in the Water Supply. E. F. KOHMAN. National Canners' Association, Washington, D. C., Circ. **4-L**: 11 pp., 1923. From Chem. Abst., **17**: 3062, September 20, 1923. Subjects discussed include: (1) Requirements of drinking water. (2) Requirements of canning water. (3) Contamination of water with taste-producing organisms, which condemns water for canning. (4) Contamination of water by industrial wastes. Case of by-product coke plant cited in detail, and several similar cases mentioned. (5) Production of foreign taste by chlorination. (6) Proportions of chlorine and phenol which cause taste. Results of numerous experiments given. Water containing by-product coke plant waste in any dilution is not suitable supply for canners. Chlorinated water is always source of danger in canning. Chlorine has been found to produce pronounced taste under conditions other than when polluted by coke plant waste.—*R. E. Thompson.*

The Effect of Hard Water in Canning Vegetables. W. D. BIGELOW and A. E. STEVENSON. National Canners' Association, Washington, D. C., Bull. No. **20-L**: 39 pp., 1923. From Chem. Abst., **17**: 3063, September 20, 1923. Effect of hard water on canning of vegetables discussed. Zeolite method is best suited for softening water for canning foods.—*R. E. Thompson.*

The Determination of Carbon Dioxide and Oxygen in Steam from Various Softening Plants. SCHIEDT and STOCKMANN. Arch. Wärmewirtschaft, **4**: 7–10, 24–6, 1923. From Chem. Abst., **17**: 3066, September 20, 1923. Data includes analyses of feed-water and of steam from various points in four plants. Typical values for carbon dioxide and oxygen respectively, in grams per ton of steam, are: lime-soda process, 12, 5; same, with blow-off water returned to feed, 37, 4; permutite softener, followed by degasifier, 62, 1; no softening, 68, 4. Much of carbon dioxide is derived from hydrolysis of sodium carbonate. In sampling, condensate must be collected under oil, as oxygen is rapidly absorbed from air.—*R. E. Thompson.*

Colorimetric Determination of Nitrates in Water. B. LAMPE. Wochschr. Brau, 39: 303–4, 1922. From Chem. Abst., **17**: 3066, September 20, 1923.

Following simple modification of Grandval and Lajoux's method for estimating nitrates in water is not affected by presence of nitrite or organic matter in small amounts usually found in natural water. Weigh Erlenmeyer flask containing 30 cc. of sample and boil with sufficient silver sulfate solution to precipitate chlorides. Cool, make up to original weight, mix thoroughly and filter through dry filter paper until clear. Evaporate 25 cc. of filtrate to dryness in porcelain dish on water bath and mix with residue, by means of flattened glass rod, 15–20 drops of reagent prepared by mixing 0.75 gram of pure phenol with 9.25 grams of pure concentrated sulfuric acid. Transfer contents of dish to 200 cc. flask, mix with 10 cc. 10 per cent ammonia solution, and make up to volume. In presence of nitrate solution is colored yellow by formation of ammonium picrate. Prepare solution containing 3.844 grams potassium nitrate per liter, dilute 10 cc. to 200 cc., evaporate 25 cc. of diluted liquid to dryness and treat as above, making up to 500 cc. after addition of ammonia. Series of flasks similar to those used for comparing colors of worts may be employed for comparing colorations. Use of 20-mm. cell containing solution of 25 grams of copper sulfate in 100 cc. increases accuracy of comparison.—*R. E. Thompson.*

Bacteriological Study of the Water of Lake Mendota. F. C. Wilson. Absts. Bact., **5**: 11–2, 1921. From Chem. Abst., **17**: 3066, September 20, 1923. Water is stratified during summer, lower water being deficient in oxygen. Bacterial count per cc. ranges from aproximately 100 in winter to 3550 in early summer. Type of bacterial flora varies with season.—*R. E. Thompson.*

The Removal of Phenols From Waste Waters of Mining. W. Gluud and R. Schönfelder. Ber. ges. Kohlenforsch, **1**: 161–8; Chem. Zentr., 1922, IV: 697. From Chem. Abst., **17**: 3067, September 20, 1923. Recommended that waste waters from mines be extracted with solvent naphtha. Experiments were carried out with tap water containing 1 per cent phenol.—*R. E. Thompson.*

Fifty-Ninth Annual Report of the Alkali Inspector, 1922. T. L. Bailey. Gas World, **79**: No. 2033 (Coking Sec.), 14–7, 1923; Gas J., **163**: 255–8. From Chem. Abst., **17**: 3074, September 20, 1923. Work begun last year (C. A. 17, 1109) on decolorizing and dephenolating waste liquors from ammonia stills by means of flue gases has been continued and further improvement made, although purification effected does not yet equal expectations. In final effluent discharged, analysis indicates volatilization of 71 per cent of phenols with reduction of 42 per cent of oxygen absorbed. Further treatment by bacterial action on specially prepared filter beds demonstrated that these liquors could be made practically innocuous in respect to phenols, thiocyanate, and other oxidizable constituents.—*R. E. Thompson.*

Corrosion of Iron in Concrete. B. Zschokke. Concrete Constr. Eng., **18**: 393–4, 1923. From Chem. Abst., **17**: 3083, September 20, 1923. Compact concrete in sufficient thickness will protect iron against corrosion for considerable time provided shrinkage cracks do not reach iron. Coating of red lead

will prevent iron from rusting for 5 years. Problem of preventing shrinkage cracks, which appear in rich oftener than in lean concrete, has not yet been solved. Inhibitive action of chromates is being studied but conclusive results have not been obtained. Following precautions for preventing corrosion of iron in concrete recommended: (1) Concrete should not be too meager, but should contain proportion of cement which will produce greatest impermeability to air. (2) There must be no substance in concrete, such as locomotive cinders, often containing sulfur, which exert chemical action on iron. (3) Layer of concrete should be of sufficient thickness to properly cover iron, and should not crack under pressure or through shrinkage.—*R. E. Thompson.*

The Protection of Concrete and Other Building Materials Against Water and Noxious Fumes. M. Toch. Ind. Eng. Chem., **15**: 665–6, 1923. From Chem. Abst., **17**: 3083, September 20, 1923. Discussion of protection of concrete, steel and wood in buildings.—*R. E. Thompson.*

Studies on the Treatment and Disposal of Dairy Waste. C. L. Walker, et al. Cornell Agr. Expt. Sta. Bull., **245**: 120 pp. 1923. From Chem. Abst., **18**: 1019, April 10, 1924. Milk waste can be successfully treated by chemical precipitation with ferrous sulfate and lime. It is unsafe to pass whey into open water currents, even after 75–95 per cent of nitrogen has been removed by precipitation with lime and filtration. Considerable data given.—*R. E. Thompson.*

Velocity of Flow by the Salt Method. Eric Crewdson. Engineer, December 14, 1923; Chem. Met. Eng., **30**: 59–60, 1923. From Chem. Abst., **18**: 1022, April 10, 1924. Accurate index of velocity of flow obtained by measurement of time between maximum voltages recorded on voltmeters connected to source of direct current (110 volts) and to electrodes, consisting of modified spark plugs, situated 100 yards apart in pipeline carrying water to which had been added 1 gallon of saturated salt solution.—*R. E. Thompson.*

The Salt Velocity Method of Water Measurement. Chas. M. Allen and E. A. Taylor. Mech. Eng., **46**: 13–6, 51, 1924. From Chem. Abst., **18**: 1024, April 10, 1924. Method of measurement similar to that described in previous abstract outlined. Passage of salt solution between two points is accurately timed and volume of pipeline between same points accurately determined. Discharge in cubic feet per second equals volume in cubic feet divided by time in seconds. Advantages claimed include: simplicity, accuracy, applicability to any form or size of flume, pipe, or penstock, economy, non-interruption of operation, flexibility, ease of obtaining records, minimum time required, and quick calculation of results.—*R. E. Thompson.*

First (Experimental) Report to the Atmospheric Corrosion Research Committee (of the British Non-Ferrous Metals Research Association). W. H. J. Vernon. Trans. Faraday Soc., 1923 (advance proof), 62 pp. From Chem. Abst., **18**: 964, April 10, 1924. Present report deals mainly with tarnishing, as distinct from corrosion in ordinary sense. Research work included both

field and laboratory experiments. Significance of shape of curve obtained by plotting weight increment against time is discussed in relation to function of corrosion product or scale, and principle involved appears to be of much importance. Three types of curve have been distinguished, as follows: (1) Parabola whose axis coincides with time axis of coördinates. Weight increment is thus proportional to square root of time, i.e., rate of attack is retarded as period of exposure increases. The scale forms continuous envelope, through which rate of diffusion of corroding atmospheres regulates attack upon underlying metal. (2) Straight line passing through origin. Weight increment is directly proportional to time, i.e., rate of attack remains constant as period of exposure increases. Scale is completely permeable, allowing free access of atmosphere to metal, itself playing neutral part. (3) Parabola whose axis coincides with weight axis of coördinates. Weight increment is proportional to square of time, i.e., rate of attack is accelerated as period of exposure increases. Scale is discontinuous and accelerates attack upon remaining metal in proportion to amount already present. Under certain conditions, particularly low relative humidity, rough surfaces show greater degree of tarnishing than smooth. In all instances differences in behaviour between hard metal and soft were exceedingly small, but wherever difference could be detected harder material was found to have undergone greater amount of change. Foregoing observations are general, being drawn from consideration of all materials investigated. Data on individual metals also given in original.—*R. E. Thompson.*

Second Report of the Relative Corrodibilities of Various Commercial Forms of Iron and Steel. J. N. Friend. Iron and Steel Institute (London) Carnegie Schol. Mem., **12**: 1–25, 1923. From Chem. Abst., **18**: 964, April 10, 1924. Effect of strain on rate of corrosion is slight, but samples employed in experiments were uniformly strained and galvanically insulated. Four types of tests were used: continuous immersion in tap water (1 year), 3 per cent sodium chloride (1 year), 0.5 per cent sulfuric acid (22 hours), and alternate wet and dry in tank which automatically filled and emptied every 2 hours. Different varieties of wrought and cast iron and carbon steels corrode in neutral media with remarkable uniformity, but in salt water wrought iron shows somewhat to advantage. In acid wrought iron is less resistant than steel, while cast iron is even more seriously attacked. Commercial pure iron is highly resistant to acid, quite satisfactorily resistant to salt water, and closely resembles other forms of iron in its resistance to tap water. With steels corrodibility in neutral media increases with carbon content up to eutectic point, followed by decrease, as previously found for acid attack; effect is not very great, however. It is most clearly seen in samples with low manganese content. Raising of manganese from 0.1 per cent to 0.5–0.9 per cent results is very slight increase in corrosion in neutral media up to 0.4–0.5 per cent manganese, and slight protection from that point up. There is, however, an enormously increased corrosion in dilute acid. These results validate conclusions previously reached. Copper in steel increases resistance to acid attack, but has little effect in neutral media. Chromium in steel increases resistance to attack in neutral media, but results with acids are variable. Nickel-chromium steel

usually resists dilute acid well. Addition of 0.4 per cent tungsten appears to be without effect on nickel-chromium steel. Field tests are in progress.—*R. E. Thompson.*

How Acid Mine Water Affects Corrosion-Resisting Metals. R. J. McKay. Chem. Met. Eng., **30**: 228–9, 1924. From Chem. Absts., **18**: 1107, April 20, 1924. M. reviews acid mine water corrosion tests (cf. C. A. **17**: 2259) and shows corrosion of monel metal to be function of ferric iron as well as of acidity. Corrosion of monel metal by sulfuric acid in laboratory tests is increased 3- to 40-fold by addition of ferric iron.—*R. E. Thompson.*

The Mechanism of Metallic Corrosion (Copper). Guy D. Bengough and J. M. Stuart. World Power, **1**: 25–34, 1924. From Chem. Abst., **18**: 963, April 10, 1924. Results of Corrosion Research Committee of British Institute of Metals discussed at length. Highly purified copper when exposed to action of moist air becomes apparently covered with thin film, particularly in presence of sulfur compounds. If copper thus covered is immersed in distilled water, microscopic examination shows that the pronoucced local darkening is accompanied by thickening and swelling of scale, finally giving rise to minute blister. In course of time scale breaks down at such points and finally minute pits are formed. Local breakdown of scale appears to be accompanied by deposition of crystals of cuprite around pit. Area covered by crystals gradually increases until finally greater part of specimen becomes covered. Presence of pores in copper immersed in distilled water does not appear to be such an important cause of local action as in case of aluminum. Much more rapid action takes place on copper placed in sea water. One of initial products of corrosion is cuprous chloride, which is oxidized in time to cupric chloride and this attacks fresh copper to form more cuprous chloride. Action appears to be decidedly electrolytic. Scale on copper after immersion in sea water consists largely of crystalline cuprite, oxychloride, and, lowest layers, cuprous chloride. It also contains considerable quantities of cupric hydroxide, probably formed by reaction between cupric chloride and alkali produced by electrolysis at cathode (metal surrounding pit). Large part of scale produced on copper is crystalline in character and not glassy and transparent as in case of aluminium. Such scale is less uniform, less adherent and more porous than glassy scale. It allows slow general attack to proceed which results in roughening of metal. Electrochemical corrosion takes place in pure copper contrary to theory of others that presence of impurities is essential for forming of couple, scale being controlling factor. Colloids probably influence corrosion phenomena but their importance has probably been overemphasized, particularly as regards pitting.—*R. E. Thompson.*

Sterilized Distilled Water. Henry Kraemer. J. Am. Pharm. Assoc., **13**: 35–8, 1924. From Chem. Abst., **18**: 1365, May 10, 1924. U. S. P. method of preparing distilled water is faulty. Method should require presence of 1 per cent sulfuric acid in still and distillation should be conducted in apparatus entirely of glass. For sterile distilled water distillate should be collected in small bottles (100–500 cc.), containers plugged with cotton, wrapped in parch-

ment, and autoclaved for 20–30 minutes at 10–15 pounds pressure. Such water will keep indefinitely, but when once opened should be discarded.—*R. E. Thompson.*

Clarification of Effluents in the Lignite Industry. H. BAHR and K. KATHER. Braunkohle, **21**: 485–7, 1922; J. Soc. Chem. Ind., **42**: 877A. From Chem. Abst., **18**: 1378, May 10, 1924. Colloids in effluents from manufacture of briquets are negatively charged and can be precipitated and liquor thus clarified by addition of positively charged colloid such as magnesium hydroxide. Latter can be prepared in solution by addition of magnesium chloride and calcium hydroxide solutions. If concentration of these solutions and their amount and method of adding be suitably controlled, clarification can be carried out in 5 minutes. Thus liquor constaining 2.5 grams of (dry) sludge per liter, requires addition of at least 6 cc. of 7.7 per cent magnesium chloride and 200 cc. of cold saturated lime water for rapid and complete clarification. Effluents containing phenols from carbonization process should not be added to liquor before clarification as phenols hinder precipitation. Water which has been used for coke quenching has opposite effect.—*R. E. Thompson.*

Gaseous Content of Ground Waters as an Aid to the Petroleum and Natural Gas Prospector. G. W. JONES, W. P. YANT and E. P. BUXTON. Bur. of Mines, Repts. of Investigations No. **2553**: 15 pp., 1923. From Chem. Abst., **18**: 1381, May 10, 1924. Simplified form of apparatus described as suitable for field determination, to nearest per cent, of carbon dioxide, oxygen, methane, ethane, and nitrogen in water. Data on analyses given showing that shallow spring waters do not contain methane and ethane but that these are found in deeper waters associated with occurrence of petroleum and natural gas.—*R. E. Thompson.*

Madison, Wis. Eng. News-Rec., **95**: 755–6, 1925. Sewage purification process employed consists of tank treatment and filtration, cost of disposal being $18.89 per million gallons, of which $5.34 is for treatment. Hardness of water supplied, derived from wells, is 300 p.p.m. No treatment is employed. Water charges average 6 cents per 100 cubic feet. Services are 100 per cent metered and per capita consumption is 100 gallons per day.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Railway Water Supply and Treatment. R. C. BARDWELL. Eng. News-Rec., **95**: 807, 1925. Of 350 billion gallons of water used annually for steam production on American railways, approximately 50 billion gallons are treated, average cost being 4 cents per 1000 gallons. Study by Committee of American Railway Engineering Association indicated that 13 cents was conservative estimate of cost—fuel consumption, repairs, and time lost—due to each pound of incrusting materials entering boilers. Least expensive method of treatment is by addition of soda ash in roadside tanks, but resulting water gives rise to acute foaming unless concentration in boiler water is kept low by frequent blowing off. Zeolite softening has not been widely employed for

railway purposes owing to high cost and excessive alkalinity of treated water and resulting foaming. Lime-soda method, carried out in roadside settling tanks, is the standard and complete method of softening.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Finding the "Critical Depth" in Hydraulic Jump Computations. Frank S. Bailey. Eng. News-Rec., **95**: 810–1, 1925. Diagram given for quickly determining critical depth of water flowing in open channels, namely, that point where energy head, i.e., depth plus velocity head, is minimum for given rate of flow.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Pipe Steel Shipped Flat then Rolled and Welded. C. A. P. Duffie. Eng. News-Rec., **95**: 872–3, 1925. Illustrated description of construction of water pipe line (16,000 feet of 30-inch and 26,000 feet of 24-inch), steel for which was shipped flat and fabricated by oxywelding. Each length of pipe was tested prior to placing and only 3 joints were returned to shop for rewelding. After testing, pipe was passed successively throuh hot alkali to remove grease, hot dilute H_2SO_4 to clean off scale, alkaline neutralizing bath, and hot rinse water. Pipe was then dried by means of gas flames playing on outside, capped at each end, dipped in asphaltum and rolled in grit.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Charleston, S. C. Eng. News-Rec., **95**: 909–11, 1925. Sewage of city drains to 9 pumping stations and is pumped into 2 rivers through series of outfalls. Water supply, which is filtered, is derived from Goose Creek. Average daily consumption is approximately 7 m.g.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Large Additional Water Supply Recommended for Boston Metropolitan District and Worcester. Eng. News-Rec., **95**: 944–6. 1925. Recommendations of Metropolitan Investigating Commission include additional supply of 180 m.g.d. to be provided in 3 installments during next 30 years at estimated cost of $85,500,000, and purification of present and additional supplies by filtration. Twenty cities and towns are at present supplied from system. Approximately 95 per cent of all services are metered and the per capita consumpton is 95 gallons per day.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Portland, Maine. Eng. News-Rec., **95**: 955–6, 1925. Water is supplied by Portland Water District from Sebago Lake, 16 miles distant. Chlorination is only treatment employed.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Salt Water in Fire Mains Speeds Corrosion. Eng. News-Rec., **95**: 956, 1925. During last 2 years, since salt water has been employed for fire extinguishing in San Francisco, leakage from high pressure system has increased from 125,000 to 225,000 gallons daily. This is ascribed to deterioration of pipes as result of accelerated corrosion and electrolysis due to salt water, and an appropriation has recently been made to provide fresh water for this purpose.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Kentucky Health Board Rates Water Supplies. F. C. Dugan. Eng. News-Rec., 95: 957, 1925. Based on character of raw water, methods of treatment, operation of plant, and analyses of water supplied, 30 of 91 water systems inspected by State Board of Health in Kentucky are rated as good, 28 as doubtful, 29 as bad, and 4 no rating but probably good. List of cities inspected with their classification, is given.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Ready Means of Estimating Quantities of Cement Materials. E. Earl Glass. Eng. News-Rec., 95: 965–6, 1925. Method of estimating described based on assumption that cement, coarse and fine aggregate all weigh approximately 100 pounds per cubic foot and that average weight of plain concrete is 145 pounds per cubic foot. Method provides means of determining approximate weight of materials required for the odd proportions encountered when mix is controlled by screening tests and fineness modulus. Accuracy is equivalent to that of methods used heretofore.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Electrically Welded Water Pipe: Tacoma's Experience. W. A. Kunigk. Eng. News-Rec., 95: 968, 1925. Experience in Tacoma, Wash., with electrically welded 30- to 60- inch steel pipe is reviewed and data on difficulties encountered given. Test bars cut from a number of sections of finished pipe, all of which were hand-welded, developed joint efficiencies of 80–100 per cent, all breaks occurring $\frac{1}{8}$ to $\frac{1}{2}$ inch from weld, except in 1 instance.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

The Engineering Year in Review and Prospect. Eng. News-Rec., 96: 49–57, 1926. **Water Works.** Ibid. 54. In the U. S. there are approximately 10,000 and in Canada about 750 communities served by public water supplies. Chicago and Milwaukee are now the only cities on Great Lakes which have not filtration plants in use or under construction. **Sewage.** Ibid. 54–5. Imhoff tank treatment, with sprinkling filters when further treatment is required, is the principal method of sewage purification employed in U. S.; use of fine screening, either alone, or with other processes, is extending.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

St. Louis Water Supply. Eng. News-Rec., 96: 84, 1926. Status of $12,000,000 water supply project is outlined. Plant, which will treat Missouri River water, will probably be in commission early in 1928.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Kansas City, Mo., Water Works. Eng. News-Rec., 96: 84, 1926. Progress in construction of filtration plant of Kansas City is reviewed briefly.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Catskill Aqueduct System. Eng. News-Rec., 96: 85, 1926. Gilboa dam, now nearly complete, will form a 20 billion-gallon reservoir and divert water of Schoharie Creek through the 600-m.g.d. Shandaken tunnel to Esopus Creek and thus into Ashokan reservoir, from which 156-mile Catskill aqueduct leads

to N. Y. City. The Gilboa dam will virtually complete Catskill aqueduct system as originally planned.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Sounding Bottle for Taking Samples of Water in Reservoirs. Carl F. Klapp. Eng. News-Rec., 95: 1083, 1925. Device for sampling water at varying depths described and illustrated.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Philippines Have Many Water Works Systems. Eng. News-Rec., 95: 1029, 1925. Including Manila metropolitan water system there were 123 water works in use in Philippine Islands at close of 1924, 35 in course of construction and 101 under consideration. Systems in use serve in excess of 378,000 people, those under construction will serve 115,000, and projects under consideration would serve 378,400.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Portsmouth, Va. Eng. News-Rec., 95: 879–80, 1925. Sewerage system to serve approximately one-third of city's area is under construction. Sewage will be pumped into Elizabeth River just beyond harbor bulkhead. Water supply of city, derived from Lake Kilby, is purified by filtration.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Half of Lowell Service Pipes Changed Within 52 Years. Robert J. Thomas. Eng. News-Rec., 95: 1041, 1925. Almost half of 15,695 services installed since 1873, first year after initial operation of water works, have been changed due to (1) corrosive action of original infiltrated and river supplies on wrought iron pipe; (2) action of later driven-well supplies on Pb and Pb-lined wrought Fe pipe, which caused Pb poisoning; and (3) leakage from Sn-lined wrought Fe pipe used in place of Pb-lined service. Cement-lined, tar-coated and rubber-treated pipes have been experimented with. Pb now predominates. Galvanized Fe has been employed during past 10 years, but little confidence is placed in its durability. If CO_2 were removed from well supplies, Pb pipe would be as effective as brass. Considerable difficulty was formerly experienced due to incrustation of pipe of all materials, including Pb, with Fe and crenothrix, but this condition has been remedied by installation of Fe removal plant.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Everett, Wash. Eng. News-Rec., 95: 841–2, 1925. Main source of present water supply is Sultan River. Peak demand is 8.6 m.g.d., or 270 gallons per capita per day. Supplementary supplies are under consideration. During past 2 years oxyacetylene welded steel pipe has been used exclusively and found highly satisfactory. As much as 800 feet of 20-inch pipe in 30-foot lengths has been welded on street surface and lowered into trench in one piece. It has not yet been found necessary to repair a welded joint, including the experimental welds made 5 years ago. Joints are covered with tar paint internally and externally after welding.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

How Laboratory Supervision Saves Omaha, Neb., $9000 per Year. Kenneth C. Armstrong. Eng. News-Rec., 96: 119, 1926. The amount of chemicals

required to effect coagulation of water at Omaha is determined by laboratory trials in series of jars, and it is estimated that employment of this method will have effected saving of $9000 during 1925 as compared with previous 6 years, notwithstanding fact that raw water was more turbid than in 1924. It has been found that addition of small dose of $FeSO_4$ ($\frac{1}{4}$ grain per gallon) enables alum dosage to be reduced from $2\frac{1}{4}$ to 1 grain per gallon. If larger amounts of $FeSO_4$ are employed, more lime is required, and it is therefore more economical to increase the alum when higher dosage of coagulant is needed. Laboratory experiments indicated that $FeSO_4$ should be added first, but in practice it has been found satisfactory to mix the alum and $FeSO_4$ in solution tanks and add the mixed solution to the water to which lime has been previously added.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Field Tests of Concrete. Cont. Rec., 39: 1007, 1925. Description and discussion of method of making slump test of concrete and of preparing cylindrical specimens for compression tests.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Water Filtration and Softening as Applied to Clay Products Plants. H. M. Marsh and W. J. McLelland. Cont. Rec., 39: 1161–3, 1925. Description of water purification plant of Don Valley Brick Works, which consists of settling and coagulation basin, mechanical pressure filter, and zeolite water softener.—*R. E. Thompson.* (*Courtesy Chem. Absts.*)

Progress in the Purification of Water Supplies. Norman J. Howard. Cont. Rec., 39: 52, 133–8, 1925. Extensive review of progress in water purification during 1925. Employment of double filtration in dealing with heavily polluted and turbid waters is extending. A solution composed of alum, Na_2CO_3, and NaOCl, concentration of latter being varied in proportion to Cl-consuming power of water, is being employed in Ontario in preparation of certain acid waters for filtration. Prechlorination and $CuSO_4$ treatment of a slow sand filter at Toronto, Ont., recently, in effort to increase length of run between scrapings in early spring when microscopic content of raw water was high, proved unsuccessful. Superchlorination and dechlorination has recently been experimented with at Toronto, Ont., as a means of eliminating medicinal taste which occasionally occurs following chlorination, and this process will be tried on large scale in near future.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Developments in Water Softening. W. J. McLelland. Cont. Rec., 39: 52, 138–9, 163, 1925. Discussion of hardness in water, its effect on boilers and in textile industry, and its removal by Clarke or lime-soda process or by base exchange. Scale $\frac{1}{30}$ inch in thickness in boilers causes fuel loss of 1–10 per cent and $\frac{1}{10}$ inch, 2–20 per cent, depending on composition of deposit.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Powdered Coal for the Des Moines Water Works Boilers. Eng. News-Rec., 96: 107, 1926. What is claimed to be first powdered coal boiler installation (designed by G. A. Conrath) for water works pumping station is described

briefly. Steam plant consists of 4 boilers, and total rated capacity is 1292 h.p. Only one boiler has been converted for use of powdered coal, but pulveriser is of capacity sufficient for whole plant. Enlarged furnace is 18 feet deep from water tubes to bottom of furnace, providing 0.5 cubic foot of furnace volume per square foot of steam-making surface. Furnace temperature is 3000°F., compared with 1800–2000° formerly. It is estimated that annual saving by new equipment, which cost $2500, including enlargement of furnace, will be $7500.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Springfield Slow Sand Filters Doubled. Eng. News-Rec., 96: 19, 1926. Water filtration plant of Springfield, Mass., has been enlarged to a little more than double original capacity—rated at 15 and operated easily at 12 m.g.d. Water is coagulated during periods when color of Little River water is noticeable and delivered into open sedimentation basin, from which, after 24 hours retention, it passes into larger basin, and thence to filters.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

St. Paul's Water Consumption and Costs in 1924. J. W. Kelsey. Eng. New-Rec., 95: 1041, 1925. Daily per capita consumption during 1924 was 76.9 gallons. As ground water is easily obtained, city supplies only approximately 60 per cent of total water consumed. Cost of maintenance during year was equivalent to $57.37 per million gallons, and total cost, including interest and sinking fund, $103.35. Services are 100 per cent metered.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

$101,028,000 Needed for Sewerage and Treatment at Detroit. Eng. News-Rec., 96: 112–3, 1926. It has been recommended that within next 7 years, $61,428,000 be expended on sewerage extensions and $39,600,000 for intercepting sewers, pumping stations, and a single treatment plant. The purification works proposed consist of bar screens, grit chambers, skimming-detritus plant, Imhoff tank sedimentation-sludge digestion plant and suitable equipment for disinfection of effluent, which will be discharged into Detroit River. In addition to sewage of Detroit and other municipalities, industrial wastes, including oil and grease, are also discharged into river, resulting in serious pollution of city water supply and of neighboring bathing beaches. Typhoid fever has been traced to latter, and their use has been prohibited by Local Board of Health.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Some Specific Factors Responsible for Pollution Affecting Analysis of Water Supplies. H. A. Whittaker. Cont. Rec., 39: 1025–6, 1925. Tabulation of factors influencing sanitary quality of water supplies.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Concrete Improved by the Use of Diatomaceous Earth. C. N. Conner. Eng. News-Rec., 95: 995–6, 1925. Experiments carried out by N. Carolina State Highway Commission indicate that addition of diatomaceous earth increases strength and promotes workability of concrete. Diatomaceous earth used was specially prepared material known commercially as celite, and was of

the plankton marine type. The average increase in compressive strength of concrete containing various percentages of celite, as compared with plain concrete, was 3 per cent at 28-day age and 8 per cent at 1 year. Increased workability when celite is employed, permits use of drier consistencies in field concrete. Field investigations with celite indicated increase of approximately 10 per cent in strength of specimens of average age of 5 months. From physical tests there is evidence of combination between free lime of cement and amorphous SiO_2. Examinations of cores drilled from plain concrete pavements show that concrete at edges varies more in quality than that in center, although average strength might be equal, probably due to greater amount of handling of edge concrete. Comparison of pavements under study shows that mean variation in plain edge concrete is about 60 per cent greater than in that containing celite. Records of projects employing celite show increased yield of concrete and lower operating costs. Specifications for diatomaceous earth for this purpose are included. Specifications call for 2 per cent in 1:1½:3 concrete; 3 per cent in 1:2:4 concrete; 4 per cent in 1:2½:5 concrete (gravel coarse aggregate); and 5 per cent in 1:2½:5 concrete (crushed stone or slag coarse aggregate). Use of over-sanded mixtures has become popular as means of securing workability. These mixtures produce workability to certain extent, but sand lacks in unit effectiveness and sacrifices density and strength. Uniformity of concrete does not appear to be increased by use of over-sanded mixtures.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Not so Favorable to Admixtures in Concrete. T. P. Watson. Eng. News-Rec., **95**: 1084 (1925). Statements of Conner (cf. preceding abstracts) are at variance with experience of Watson, which has been that compressive strength of concrete is dependent on cement-water ratio of mix, irrespective of proportions, with or without admixtures. Use of latter necessitated in all cases additional water to obtain same workability, which reduced compressive strength accordingly. Careful proportioning of concrete mixtures with graded aggregates will ensure satisfactory workability. If arbitrary proportions are specified and additional workability is required, it will usually be more economically accomplished by employing additional cement.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Concrete Admixtures. G. W. Hutchinson. Eng. News-Rec., **96**: 129–30, 1926. Criticism of Watson's discussion (cf. previous abstract).—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

More on Concrete Admixtures. G. M. Williams. Eng. News-Rec., **96**: 129, 1926. Discussion of article of Conner (cf. previous abstracts), with special reference to "oversanded" mixtures, which are shown to be superior under certain conditions, fineness of sand, expressed as surface area, being controlling factor. Sands having surface area of less than 700 square inches per 100 gallons permitted use of 1.0 sand-gravel ratio, while sand approaching 1100 square inches gave best results with 0.5 ratio. In the case of a Saskatchewan sand of surface area of 350–500 square inch ratio of 1.0–1.5 gave best quality concrete, which was stronger and more easily placed than mixtures

conforming to 2:4 and 3:6 ratios. These "oversanded" concretes require a greater quantity of mixing water and are less dense but more watertight or impermeable.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

The Sterilization by "Ferrochlor" of Water of Rivers Used as City Supply. Noël Adam. Rev. universelle des Mines, February 15, 1924; Le Genie Civil, **84**: 387–388, 1924. Hypochlorites and ferric chloride are used. Material added therefore contains hypochlorous acid, ferric oxide, and a ferrate, and is energetic bactericide. Process has been used for some years at Middelkerk, Belgium, and at Letoure, France. Experiments made at Paris indicate that dose at latter would not be more than 4 or 5 grams hypochlorite per cubic meter.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Construction of Galleries Under Pressure in Impermeable or Fissured Terrains. Schweiz. Bauzeitung, October 31, 1925; Le Genie Civil, **87**: 539–540, 1925.—*Jack J. Hinman, Jr.*

Water Supplies of the Communes in the Vicinity of Paris. Le Couppey de la Forêt. La tech. sanit., **20**: 247–248, 1925. Water of the Compagnie des Eaux de la Banlieu is taken from Seine at Suresnes, put through pre-filters and slow sand filters, and chlorinated.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Problem of Supplying Potable Water for the Paris District. Fernand Laurent. La tech. sanit., **20**: 245–7, 1925. Consumption in 1913 was about 280,000 cubic meters per day. Recently it has exceeded 600,000 cubic meters in hot weather. Additional sources of water supply are needed to care for needs of city.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Sinking Artesian Wells by American Methods. H. Vigneron, La tech. sanit., Rotary drilling by Layne method, using mixture of water and clay. Earth is consolidated by injection of clay for several meters beyond drill hole and openings through pervious strata above desired aquafer are thus closed.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Water Supply for Northern New Jersey. Pub. Works, **57**: 13-16, 1926. Chimney Rock project recommended by Northern Jersey District Water Supply Commission for supplying this section with water is described. Chimney Rock site was chosen because of its many natural advantages. A 66,000 million gallon reservoir could be built at this site with connections to 160 square miles of drainage area. Cost of reservoir and connections to drainage area with aqueducts to center of Six Counties is estimated at $46,000,000. This would yield supply of 150 million gallons per day. Analyses showed water to be of excellent quality so that filtration would not be needed during early years. Supply to Chimney Rock reservoir could later be developed to yield a total of 750 million gallons per day which would satisfy estimated requirement of District in 1970.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Improving Boston Metropolitan Water Supply. Pub. Works, 57: 17–18, 1926. Report of Metropolitan Water Supply Commission is reviewed. Filter plant is recommended to treat the 26 million gallon per day South Sudbury supply. To supply immediate needs, construction of dam on Ware River, thereby creating reservoir which would supply 45 million gallons per day, is recommended. This development would cost $14,000,000. Three projects to be developed later which would add 47, 80, and 50 million gallons per day to the supply at costs of 8.5, 19, and 12 million dollars respectively are also recommended.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Tampa's New Water Works. Pub. Works, 57: 1–6, 1926. Complete description of new water works is given. Old supply was obtained from twenty ten-inch wells from 165 to 328 feet deep with total capacity of 6 million gallons per day. This supply had become unsatisfactory on account of high salinity; but it will be maintained as a reserve. New supply is taken from Hillsboro river. River water has color range from 26 to 200 p.p.m. and hardness range from 30 to 200 p.p.m. Period of maximum hardness coincides with that of minimum color. Low-lift pumps take water from intake wells to first mixing chamber whence it flows by gravity through entire plant to filtered water reservoir. It is then pumped through 3 miles of 30-inch force main to distribution system and to three elevated tanks each of 500,000 gallons capacity. Pumping and purification plants are designed to handle 12 million gallons per day with provision for 25 per cent overload. Lime will be added in first mixing chamber for softening. Sulphur dioxide will be added with alum for decolorizing.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst*)

Nine Charts for Flow of Water in Channels. George Higgins. Eng. and Cont., 64: 607–13, 1925. Diagrams to facilitate hydraulic computations are presented.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Combined Reservoir and Tennis Court. Waldo E. Smith. Eng. and Cont., 64: 1254–55, 1925. A 2 million gallon ring tension type reinforced concrete reservoir for Ponca City, Oklahoma is described. Reservoir is 160 feet in diameter with inside depth of 15 feet and is provided with 10 by 10 by 12 feet sand trap where incoming line enters. Floor is from 6.5 to 11 inches thick; wall is uniformly 14 inches thick; and mushroom type reinforced concrete columns 16 inches in diameter are placed 20 feet apart each way. The roof is 6-inch reinforced slab and will provide two tennis courts.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Municipal Water Softening. W. C. Hirn and E. F. Eldridge. Eng. and Cont., 64: 1281–88, 1925. The first small water softening plant in U. S. was installed at Oberlin, Ohio, in 1904. By 1915 there were 7 important plants in U. S., and since then 19 additional plants have been put into operation. Water softening was developed rapidly by the railroads, first plant being installed in 1906; by 1914, 348 plants were being used by lines of middle west. Chemistry of water softening is briefly discussed and two diagrams for calculating hardness and amounts of lime and soda ash required are presented.

Cost of a water of average hardness in State of Michigan to city of 10,000 is calculated at $2.07 per capita per year. It is shown that cistern supply of soft water for such a city would cost $4.20 per capita per year. Cost of water softening for same city is calculated to be about $1.02 per capita annually. Public's objection to softened water on score of palatability was shown to be groundless by experiments at Lansing.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

NEW BOOKS

Drainage and Flood-Control Engineering. Geo. W. Pickels. New York and London: McGraw-Hill Book Co. Inc. Cloth: 6 by 9 inches; pp. 450. $4. Reviewed in Eng. News-Rec. 95: 1002–3, December 17, 1925.—*R. E. Thompson.*

The Economics of Public Utilities. L. R. Nash. New York and London: McGraw-Hill Book Co., Inc. Cloth; 6 by 9 inches; pp. 430. $4. Reviewed in Eng. News-Rec. 95: 1004, December 17, 1925, and Munic. Eng. 76: 723, December 24, 1925.—*R. E. Thompson.*

The Chemistry of Power Plant. W. M. Miles. Ernest Benn, Ltd. pp. 144. 6s., by post 6s. 4d. Reviewed in Munic. Eng., 76: 722, December 24, 1925.—*R. E. Thompson.*

Technical Plumbing and Sanitary Science. S. Barlow Bennett. B. T. Batsford, Ltd. 4th. Ed. pp. 285. 9s. 6d., by post 10s. Reviewed in Munic, Eng., 76: 676, December 10, 1925.—*R. E. Thompson.*

Introduction à l'étude des colloides. L'état colloidal et ses applications. W. Kopaczewski. 16mo (18.5 x 12 cm.) 220 pages, 38 figs., Gauthier-Villars et Cie., publishers, Paris. Noted in Le Genie Civil, 87,475 1925.—*Jack J. Hinman, Jr.*

Théorie général et formulaire pratique du ciment armé. Charles Amar, 8vo, 179 pages, many figs and plates. Gauthier-Villars et Cie., publishers, Paris. Noted in Le Genie Civil, 87: 524, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Turbines hydrauliques. A. Rateau, D. Eydoux and M. Garill, 8vo, pp. 692, 178 figs., J. B. Baillière et fils, publishers, Paris. Noted in Le Genie Civil, 87: 524, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

VOL. 15 JUNE, 1926 No. 6

CONTENTS

OFFICERS OF THE AMERICAN WATER WORKS ASSOCIATION

OFFICERS OF THE AMERICAN WATER WORKS ASSOCIATION (Continued)

Central States Section.—President, JOSEPH W. ELLMS, Vice-President, CHESTER F. DRAKE; Secretary, E. E. BANKSON; Trustees, J. C. BEARDSLEY, D. C. GROBBEL, MENTOR HETZEL.

4-States Section.—President, EDGAR M. HOOPES, JR.; Vice-Presidents, V. BERNARD SIEMS, L. VAN GILDER; Secretary-Treasurer, CHARLES R. WOOD; Executive Committee, N. E. BARTLETT, W. H. BOARDMAN, H. D. BROWN, J. W. LEDOUX, GEORGE MCKAY, and the officers.

Illinois Section.—Chairman, W. R. GELSTON; Vice-Chairman, G. C. HABERMEYER; Treasurer, H. E. KEELER; Trustees, H. M. ELY, L. R. HOWSON, C. M. ROOS.

Indiana Section.—Chairman, J. O. ENDRIS; Vice-Chairman, WM. LUSCOMBE; Secretary-Treasurer, C. K. CALVERT; Assistant Secretary-Treasurer, B. J. T. JEUP.

Iowa Section.—Chairman, HOMER V. KNOUSE; Vice-Chairman, J. W. MCEVOY; Secretary-Treasurer, J. J. HINMAN, JR.; Directors, THOS. J. SKINKER, C. D. HAYS.

Kentucky-Tennessee Section.—Chairman, C. E. DAVIS; Vice-Chairman, W. S. PATTON; Secretary-Treasurer, F. C. DUGAN; Directors, F. W. ALBERT, W. H. LOVEJOY.

Minnesota Section.—Chairman, J. A. CHILDS; Vice-Chairman, FELIX SELIGMAN; Secretary-Treasurer, ARTHUR F. MELLEN; Trustees, OLE FORSBERG, A. D. HORNE, E. MCCULLOH.

Montana Section.—J. F. WILLETT, President; H.B. FOOTE, Secretary-Treasurer.

New York Section.—President, B. B. HODGMAN; Secretary, E. D. CASE; Board of Governors, E. D. CASE, B. B. HODGMAN, F. T. KEMBLE, THADDEUS MERRIMAN.

North Carolina Section.—President, J. O. GRAIG; Vice-President, M'KEAN MAFFITT; Secretary-Treasurer, THORNDIKE SAVILLE; Executive Committee, G. F. CATLETT, E. G. MCCONNELL, H. E. MILLER, A. O. TRUE, W. E. VEST, and the officers.

Wisconsin Section.—Chairman, W. D. LEONARD; Vice-Chairman, EDWARD BROWN; Past Chairman, L. A. SMITH; Secretary-Treasurer, C. M. BAKER; Director, WILLIAM KOEHN.

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

VOL. 15 JUNE, 1926 No. 6

CROSS-CONNECTIONS IN CHICAGO[1]

BY ARTHUR E. GORMAN[2]

The history of American water works is marred by the record of many serious outbreaks of typhoid fever and other intestinal diseases resulting from contamination of public water supplies by polluted water which entered the distribution system through cross-connections. As an aftermath of these experiences health and water works officials in this country will now generally be found in agreement on a policy requiring a physical disconnection of the public water system from all other water systems. While the writer is in full accord with this principle for new installations, he is of the opinion that a rigid enforcement of this policy may not infrequently impose a severe hardship upon certain industries and require expenditures quite out of proportion to the potential danger to the public health. This position is taken after two years intimate contact with the work of eliminating cross connections with the Chicago water works system.

In February, 1924, under the direction of the writer, a systematic survey of cross-connections was begun by the Chicago Department of Health and is still in progress. Very much to our surprise 491 illegal connections were found in the twenty-three months ending January 1, 1926. A compilation of these connections by size and types is given in table 1.

[1] Presented before the Illinois Section meeting, March 25, 1926.

[2] Chief Sanitary Engineer, Division of Water Safety Control, Bureau of Engineering, Department of Public Works, Chicago, Ill.

Before demanding the breaking of cross-connections the health or water works official may well investigate the reasons for their existence. He will usually find that these may be classified in three groups:

1. Inability of the public system to supply adequate pressure or sufficient quantity of water.
2. A desire for economy.
3. Convenience of operation.

TABLE 1

SIZE	TYPE OF CROSS CONNECTION		TOTAL	PER CENT OF TOTAL
	Direct	Indirect		
inches				
½	4	17	21	4.3
¾	22	31	53	10.8
1	13	19	32	6.5
1¼	4	34	38	7.7
1½	11	7	18	3.7
2	48	57	105	21.4
2½	10	8	18	3.7
3	25	32	57	11.6
3½	1	0	1	0.2
4	32	37	69	14.0
5	1	0	1	0.2
6	13	24	37	7.5
8	4	10	14	2.9
10	1	3	4	0.8
12	3	11	14	2.9
14	0	3	3	0.6
15	1	1	2	0.4
16	0	2	2	0.4
18	1	1	2	0.4
Total.......	194	297	491	100.0

Obviously, in cases where the public water works system cannot render adequate service, the consumer's problem is entitled to every consideration consistent with safety to the public health; in fact, the success of any campaign against cross connections will depend to no small degree upon the attitude of the health or water department in cases of this kind.

Cross-connections in large buildings and industrial plants cannot ordinarily be removed immediately without incurring risks to life and property, and the problem of the consumer in these cases is no

slight matter. It has been our experience in Chicago that by taking proper precautionary measures in the meantime, a patient attitude on the part of the public official will result in an early compliance with recommendations. It must be borne in mind that in many cases the expense involved is considerable and that those in immediate charge must obtain permission from general managers, or even Boards of Directors, before full compliance can be effected. In the instance of one large company in Chicago, which was being operated under the direction of a receiver appointed by the Federal court, it was necessary to obtain authority from the court to incur expenditures found necessary to make equivalent substitution for a dangerous cross-connection.

Where a dual water system is used merely for the sake of economy, the public supply being cross-connected for use in emergencies, the conditions are entirely reversed and the demand for an immediate separation from the city water system is not unreasonable. In such cases the safety of the public water supply may have been continuously in jeopardy while the city stood ready to give emergency service to the private consumer, for which its remuneration might be insignificant.

Cross-connections of convenience should never be tolerated.

In Chicago cross-connections are divided into two classes:

1. *Direct cross-connections*—where there is or may be a differential pressure between the two systems, permitting a flow from the secondary system into the city water lines in case of leakage past a valve or valves.

2. *Indirect cross-connections*—where the two systems are physically connected, but prevailing conditions are such that the possibility of flow from the secondary system into the city water lines are extremely remote.

A physical separation of the two systems has always been requested where direct cross-connections were found. The justice of this stand has been uniformly recognized and with a few exceptions prompt compliance with the regulation of the Department of Public Works, forbidding cross-connections, has followed the official notification. This regulation, which appears in the Rules and Regulations governing service pipe installations, issued by the Division of Water Pipe Extension, Bureau of Engineering is as follows:

Wherever a system of water supply piping is installed either inside or outside of buildings, in streets or alleys or other public or private property which

receives its supply from any well, cistern, river, pond, lake or any other source except the water supply system of the city, such systems shall be kept entirely separate from and no connections of any kind, either direct or indirect, shall be made with any pipe or system of piping which receives its supply from the water supply system of the city.

Early in the campaign the department made a valuable contact with the Chicago Board of Fire Underwriters, whose chief engineer adopted a policy which is not only legally sound, but also has been of material assistance in certain cases where stubborn resistance was anticipated. He advised that where the Underwriters had allowed credit on the insurance rate for the existence of an illegal connection with the public water system, this credit would be removed when notification of the illegal cross-connection was received.

The cross-connection investigation was not confined to connections between secondary water systems and the public water supply, but was extended to all types of connections through which water used by the public might be exposed to contamination. This led into a special study of swimming pools, house filters, ice plants, condensers, underground reservoirs, roof tanks and many other water systems common to modern standards of living and to industries where large quantities of water are consumed.

As sewage is the most important source of infection, special attention was given to connections between water systems and waste connections to sewers. This phase of our problem was a particularly acute one because in certain sections of Chicago the capacity of the sewer system is inadequate and following heavy rainfalls serious flooding is a frequent occurrence. The public health officer in a city where the sewer system is inadequate may well consider all points below the elevation of flood level in sewers as a zone of potential pollution and be governed accordingly. Obviously the manufacture of ice or the storage of food supplies in places below sewer grade in districts subject to flood is jeopardizing the public health.

While it is self-evident that the health and water departments should coöperate fully to safeguard the public water supply, it is my opinion that there can and should be established definite limits of responsibility for these two agencies. It is my belief that the water department should be responsible for the sanitary quality and safety of the public water supply up to the point of delivery to the consumer, either to the curb line or to the inside of the meter. Therefore, this department should be responsible for all cross-connections with the

public water distribution system. On the other hand, the uses which are made of water by consumers, and the handling and exposure of this water after delivery to the meter, are matters of concern to the health department, since the health of large groups of persons may be so jeopardized. For example:

The water supply to a large hotel as delivered is safe. The hotel management, for reasons of its own, elects to filter this water through pressure filters and to store it in an open cooling tank located in the basement, from which tank the chilled water is re-circulated throughout the hotel by special pumping units (see figure 3). Sewage from an overhead house line, passing through the basement, drips into

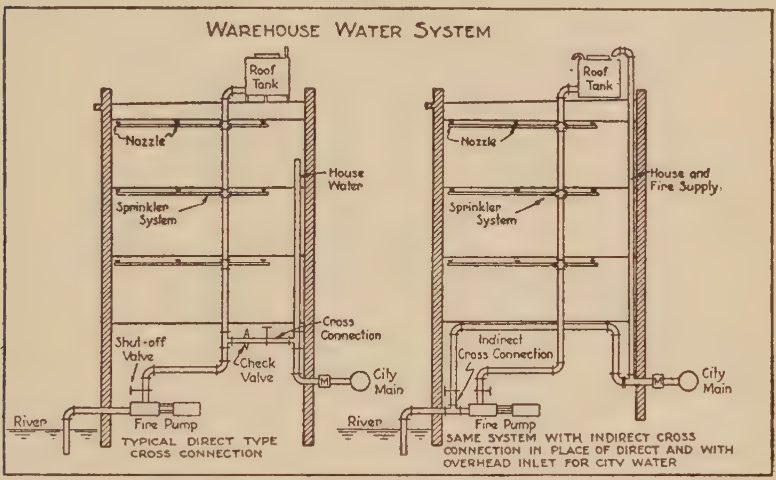


FIG. 1. WAREHOUSE WATER SYSTEM

the tank, with the result that a severe outbreak of diarrhoea develops among patrons of the hotel. The water department is, in my opinion, in no way to blame, responsibility for the water system within the hotel being a function of the health department.

Although the Chicago survey developed a myriad of cross-connection conditions which had to be worked on individually, in accordance with the local details, I have chosen to illustrate by diagrammatic sketches typical cases which are considered of special importance.

Figure 1 is typical of a great many cross-connections found at warehouses located along the Chicago and Calumet rivers and their

tributaries. The cross-connections in these cases were usually made through carelessness or with the object of saving the expense of a special city water line to the roof tank, which expense, of course, had to be met later to give the protection desired.

Where difficulty with clogging of the river suction to the fire pump was experienced the indirect type of cross-connection shown to the left was not objected to provided the fire pump was of the reciprocating type. In case the fire pump was a centrifugal pump the indirect cross-connection was not permitted during the winter season when dangers of freezing of the river suction existed. Note also that

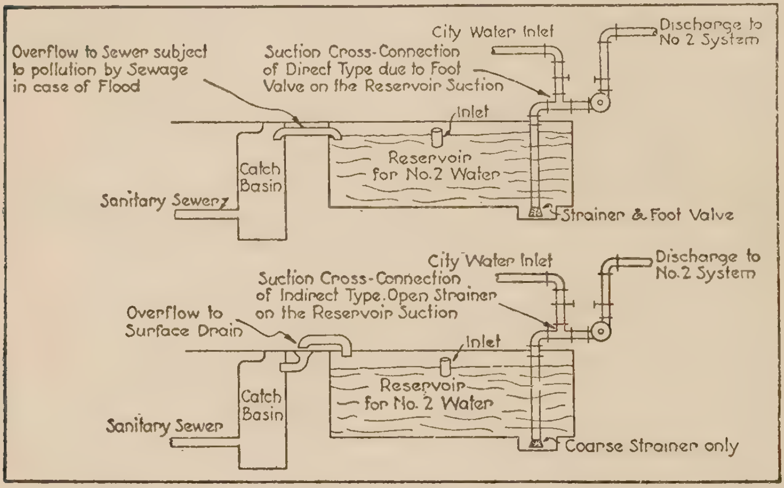


FIG. 2. WATER SYSTEM AT LARGE PLANTS WHERE CONDENSER WATER IS COLLECTED FOR RE-USE AND MISCELLANEOUS SECOND USES

no valve is permitted between the pump and the river suction, so that contaminated water from the roof tank cannot enter the indirect cross-connection to the city main.

Figure 2 illustrates another type of indirect cross-connection not objected to in cases where the supply of city water is inadequate. The system illustrated is typical of many existing at packing plants in the Union Stock Yards where water which is passed over condensers is collected in reservoirs and re-used in what is called the No. 2 system. This water may be re-used in the condensers or pumped to various plants for general washing and cleaning purposes, where the quality of the water is not of prime importance. The No. 2 system

is also essentially the emergency reserve for fire fighting purposes. To require a separation of these indirect cross-connections would cost the companies concerned many thousands of dollars, which expense would be out of proportion to the risk to the public health involved. In several cases dangerous connections were found, and it may be said to the credit of the companies concerned that they acted promptly to correct them. Of course, where the pump in the No. 2 system was of the centrifugal type, and the suction from the reservoir was equipped with a foot valve for priming purposes, what appeared to be an indirect cross-connection was in reality a direct cross-connection. In these cases removal of the foot valve

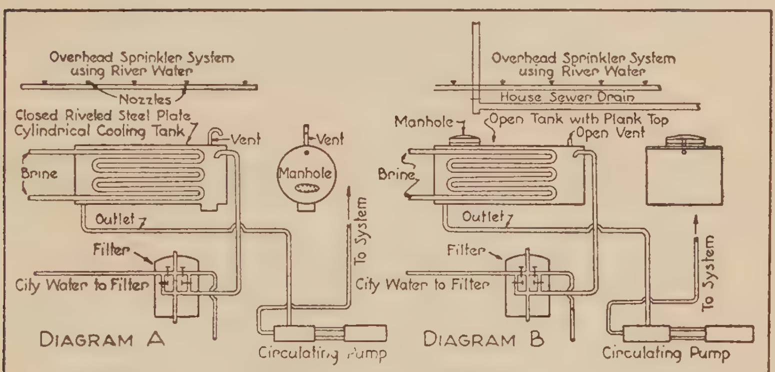


Fig. 3

Diagram A. House tanks or surge tanks should not be open at the top; vents should turn downward.

Diagram B. House water system exposed to overhead sources of pollution. This system is also typical of many with open surge tank installations.

and any valves between the reservoir suction and the centrifugal pump was required. Overflow connections to sewers were altered, as shown in the diagram, so that the possibility of sewage flowing back into the reservoir was eliminated.

Figure 3 illustrates a typical installation where city water is stored in a tank and re-circulated within a building or plant. In a number of plants open surge tanks were used without due care being taken to see that there were no sources of contamination above the tank. In general, the use of open tanks is to be discouraged in favor of closed tanks properly vented. In any case before the location of a storage tank is selected it should be made certain that the water in

the tank will not be affected by possible leakage from a sewer drain or sprinkler water from the fire system.

Figure 4 is typical of the swimming pool installation in many institutions in Chicago. To begin with it should be noted that the swimming pool and the filters are directly connected to the sewer and located below the flood level. These conditions are open invitations to trouble in case of leaking valves. In one institution a report was received that following heavy rain storms sewage had even backed up through the floor drains under shower baths.

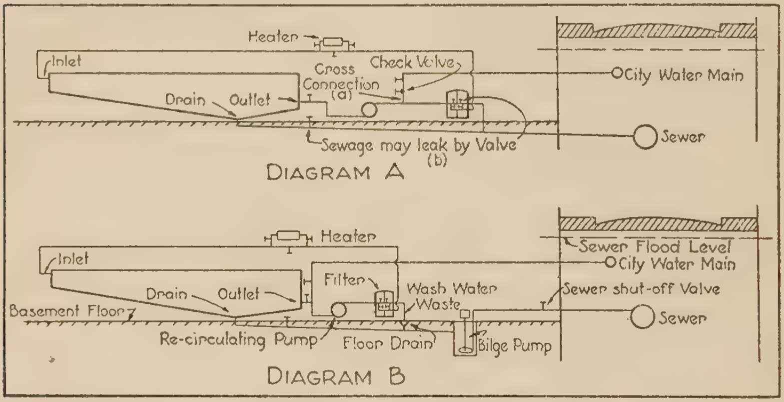


Fig. 4

Diagram A. Common type of water supply and drainage system for basement swimming pool with re-circulating equipment. *a*, cross-connection between city and re-circulating water systems; *b*, filter and pool subject to pollution by flood water from sewers.

Diagram B. Thompson water supply and drainage system for swimming pools with re-circulating equipment. *a*, no cross connections; *b*, filters and pool protected against back water from sewers.

To eliminate these direct connections with sewers the Department of Health recommends that all drainage from swimming pools, and the wash-water from filters, discharge into open sump or bilge tanks and that this waste water be re-pumped to the sewers. Of course, to prevent the flooding of the basement the discharge line to the sewer should be equipped with a shut-off valve.

In Chicago it is very common for large office and apartment buildings to filter the city water supply, using pressure filters. Frequently these filters are located in the basement and the wash-water waste line from the filter is directly connected to the sewer system. Where

such conditions exist flooding of the sewer might result in gross pollution of the filter in case of a leaky valve. It has been the policy of the department to require filter waste lines to discharge either into open floor drains or into a funnel opening connected to the drain. It is the opinion of the writer that architects and designers should give more attention to the location and design of swimming pools and pressure filter units. Where practical these tanks should be located above flood level in the sewer system.

Attention is directed to the cross-connection shown between the city water system and the re-circulated water in the swimming pool system. Such connections were found to be common practice. As a rule pressure in the re-circulating system is not over 20 pounds per square inch and most of the time the city pressure is in excess of this; however, there are periods when the reverse would be true and if valves are not tight re-circulated water might enter the city system. This cross-connection is apparently made to permit washing of the filter with the city water and to allow for filtering of the city water used for filling the tank or for make-up purposes. Where such cases existed the Department of Health recommended a change in piping connections so that the city water instead of being connected on the discharge of the re-circulating pump is connected on the suction. This system was developed in Chicago by Plumbing Inspector John R. Thompson and has met with general favor. It will be noted that back-pressure against the city water mains is not possible, on account of the open swimming pool "floating on the line." With this system, however, all water must pass through the re-circulating pump. The filters can still be washed under city pressure, the wash-water passing through the re-circulating pump. It might be necessary to arrange to disconnect the drive shaft at the motor on the re-circulating unit or to change the type of motor to permit the operation of the pump under the change of conditions.

Another common type of cross-connection in Chicago is between hot water and boiler feed systems and the city mains. Since only city water is used in these systems the danger to the public health is reasonably remote providing no injurious foreign substances are used for treating the water within the building; however, in any case there is need for protecting the meter against exposure to hot water on account of the danger of warping of the hard rubber parts in the meter. Figure 5 illustrates a piping system to a hot water heater, which was found, upon investigation, to be the cause for a complaint

of blue water coming from the taps within the building. At the address referred to there were three stores. The city water entered in the basement of the owner's store and each tenant's space was equipped with a small hot water system, as shown in the diagram.

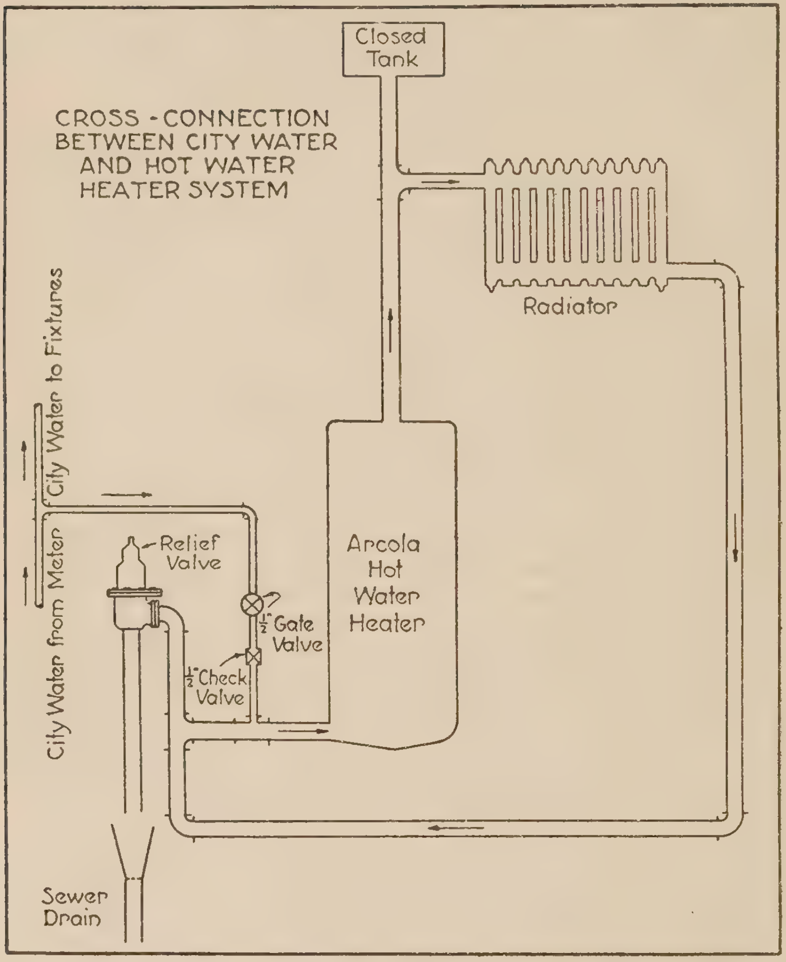


Fig. 5. Cross-connection Between City Water and Hot Water Heater System

Gate valve open, check valve defective and blow-off pressure of relief valve higher than city water pressure. Sealtite compound placed in hot water boiler was forced into city water system, causing intermittent blue discoloration of water in building.

Two of the tenants complained of blue water, but consumers in adjacent premises were not troubled in this way. An investigation revealed the fact that the gate valve to the heater in one of the stores was open and that the check valve was not operating. The investigator also learned that on account of water leakage from one of the radiators the landlord had, prior to the receipt of the complaint, purchased a patented product for sealing radiator leaks, composed chiefly of shellac, which in accordance with instructions he placed in the heater. This sealing compound was made up with a blue dye and consequently when the pressure in the hot water system was greater than in the cold water system the blue dye passed from one system to the other and appeared in the lavatories in two of the stores. It was indeed fortunate that this dye was used and that the compound contained no poisonous material. In talking with certain plumbers who have had a wide experience with conditions in Chicago the writer was informed that it was entirely probable that there were at least 50,000 similar connections in the city.

In conclusion, it is desired to state that while no cases of typhoid fever in Chicago have been directly traceable to cross-connections, the very existence of nearly 500 potentially dangerous cross-connections with other sources of supply indicates the importance of careful inspection and follow-up work by health and water departments in large cities where water supply systems of many types may be found.

The field work on cross connections in Chicago was carried out under the immediate direction of Chief Sanitary Inspector Chas. B. Ball and the inspections were made by plumbing inspector John R. Thompson and Charles Mulcahy to whom the writer is indebted for information contained in this report.

PREVENTION OF CORROSION AND "RED WATER"[1]

By John R. Baylis[2]

Any estimate of the economic loss due to corrosion of iron pipes throughout the United States would be merely a guess, but it is probably between fifty and one hundred million dollars annually. This statement is not to convey the impression that pipe repairs and replacements due to corrosion are costing the water works this amount, but when everything is taken into consideration, such as pipe repairs made by the water departments, repairs made by the consumers, loss of water through leaks caused from corrosion, damage to property from leaks, the necessity for larger pipes when it is known that the carrying capacity will be greatly reduced by the formation of iron rust, fire losses due to inadequate water pressure caused from a partial stoppage of the mains, staining of bathroom fixtures, staining of clothes being laundered, and probably other losses, the total loss is quite a large figure. That this amount may be materially reduced with a reasonable expenditure for proper treatment of the water, and that the public will be much better satisfied with non-corrosive water, are facts not fully appreciated by most water works officials.

There was a feeling in the past by the general public that water was one of nature's products and should not be changed, except to strain out the suspended matter. With this opposition it is remarkable that such progress as has been made in improving the sanitary quality of our water supplies was possible. In the attempt to give clear, pure and palatable water we have in many instances increased corrosion troubles, and occasionally to the extent where it is doubtful if the gain in sanitary safety so greatly overbalances the burdens imposed by corrosion. It is the purpose of this article to show that corrosion may be materially reduced at an actual saving to the public, and that this should be the next step in the progress of water treatment.

[1] To be presented before the Buffalo Convention, June, 1926.

[2] Principal Sanitary Chemist, Bureau of Water Supply, Baltimore, Md.

THE THEORY OF CORROSION

Before taking up the methods of treatment to prevent corrosion it is desirable briefly to explain the manner in which corrosion takes place, for unless there is a fair conception of the fundamental factors influencing corrosion rates it will be difficult to know how best to treat the water. There is a slight tendency for iron to go into solution, and if the reaction is electrochemical as suggested by Whitney[3] in 1903, the Fe ions take up a positive charge from the hydrogen ions of the solution, liberating atomic hydrogen (H). That is, Fe will replace a few of the hydrogen ions of the dissociated water giving $Fe^{++} + 2(OH^-) + 2H$. Bancroft[4] states that any chemical reaction which can be split into an anode part and a cathode part may be an electrochemical reaction. For the reaction of iron to proceed to the point of producing a ferrous hydroxide precipitate it is necessary that the atomic hydrogen be disposed of in some manner. There are two ways in which this may take place, one to combine with oxygen to form water and the other to be liberated as hydrogen (H_2) gas. When dissolved oxygen is present in alkaline solutions most of the hydrogen will combine to form water, but in acid solutions the reaction may be largely the liberation of hydrogen gas. Between these extremes the reaction may be both ways, and for most natural waters the oxidation of the hydrogen is probably in excess of the liberation of gas. It very likely is greatly in excess when a fresh iron surface is exposed, but when corrosion is taking place beneath a coating of iron rust there probably are cases when a large amount of negative ions other than the OH^- ions are present in which the prevailing reaction is the liberation of hydrogen gas, even when the water outside of the rust contains an abundance of dissolved oxygen.

Whitman and Russell[5] assume the anodic reaction in the case of acid corrosion of metals to be M (metal) $+ \oplus = M^+$, and that the cathodic reaction is either $H^+ = H + \oplus$, or $\frac{1}{4}O_2 + \frac{1}{2}H_2O = (OH)^- + \oplus$. Such a reaction accounts for the corrosion of metals below hydrogen in the electromotive series when oxidizing agents are present. If the reaction of iron is electrochemical it must react direct with the water of some electrolyte. In the absence of acids

[3] Whitney, Jour. Amer. Chem. Soc., 25, 394 (1903).

[4] Bancroft, Ind. and Eng. Chem., 17, 336 (1925).

[5] Whitman and Russell, Ind. and Eng. Chem., 17, 348 (1925).

the first product of corrosion is assumed to be the reaction with water to form ferrous hydroxide, but in their presence no reference is found as to whether the assumption is that the first product is still ferrous hydroxide, or that the Fe^{++} unites directly with the negative ions of the acid. The reaction $\frac{1}{4}O_2 + \frac{1}{2}H_2O = (OH)^- + \oplus$, given as a possible reaction, leads one to believe it is assumed that the reaction may at first be with the OH^- ions and is later replaced by other negative ions. The writer is more inclined to accept Bancroft's explanation that the formation of the salt is the anodic reaction and the liberation of hydrogen gas the cathodic reaction with acids (2). "When zinc dissolves in hydrochloric acid, the formation of zinc chloride is the anode reaction and the evolution of hydrogen gas the cathode reaction."

The reaction of iron in pure distilled water containing only dissolved oxygen is:

$$\text{(1)} \qquad \frac{\text{Fe(soluble metal)} + 2+\text{(positive electrons)} = \text{Fe}^{++}\text{(ionic)}}{\text{Anode reaction}}$$

There must occur simultaneously at the cathode

$$\text{(2)} \qquad \frac{\text{H}^{+}\text{(ionic)} = \text{H (nascent)} + + \text{(positive electron)}}{\text{Cathode reaction}}$$

Fe having replaced the hydrogen in dissociated water, there is at first produced ferrous ions, but as the concentration of ferrous ions increases molecular ferrous hydroxide is produced.

$$\text{(3)} \qquad \text{Fe}^{++}\text{(ionic)} + 2(\text{OH}^-)\text{ (ionic)} = \text{Fe(OH)}_2\text{(molecular)}$$

For reactions 1, 2 and 3 to progress there remains atomic hydrogen (H) to be disposed of in some manner. Since the solution pressure of metallic iron is not sufficient to produce hydrogen gas (H_2) at ordinary water temperature apparently the only way by which corrosion can progress in pure water is by the oxidation of the atomic hydrogen.

$$\text{(4)} \qquad 2\text{H(atomic)} + \tfrac{1}{2}\text{O}_2\text{(dissolved)} = \text{H}_2\text{O(water)}$$

Corrosion in natural waters containing dissolved salts, carbonic acid and dissolved oxygen is largely by the above reactions in the early stages, but soon they begin to change and much of it may be by the same manner in which acids combine with iron.

$$\text{(5)} \qquad \text{Fe}^{++}\text{(ionic)} + \text{negative ions of acid} = \text{ferrous salt}$$

In this case the hydrogen may be either oxidized or liberated as H_2 gas. It is also probable that ferrous hydroxide is still the first product and it later exchanges the OH^- ion for some other negative ion. It probably makes no difference, however, in actual practice which way the reaction takes place so long as the final product is a ferrous salt.

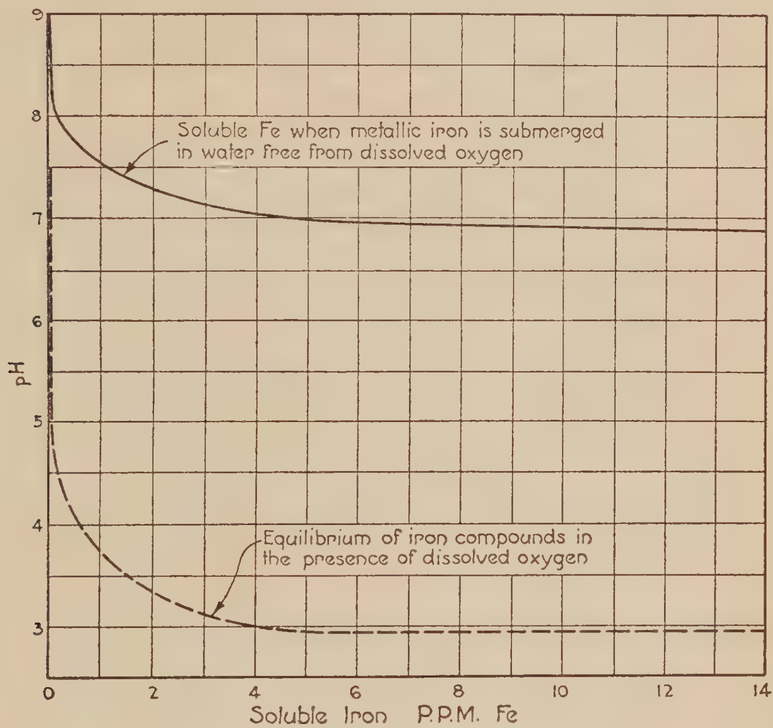


FIG. 1. RELATION OF pH TO SOLUBLE IRON

SOLUBILITY EQUILIBRIUM OF IRON SALTS

The fact that most of the corrosion in old water pipes probably is taking place in the same manner as acids combine with iron, it is desirable to know something of the equilibrium of the iron salts in contact with metallic iron. A large number of tests have been made to determine the equilibrium of soluble iron when metallic iron is in the presence of solutions having various pH values. The upper curve in figure 1 shows the amount of soluble iron which might be

expected when iron in the absence of dissolved oxygen is in contact with most natural waters having an alkalinity of about 40 and containing carbonate compounds. Points for the establishment of this curve were from quite a large number of tests and are to be published in another article. There is some variation due to the concentration of soluble compounds in the water, but the effect is of minor importance compared to that of pH. Practically no soluble iron exists at a pH of 8.0, and a saturated solution of ferrous sulfate in the presence of metallic iron and in the absence of dissolved oxygen is at a pH near 6.0. This, of course, does not mean that when metallic iron is placed in a natural water having a pH of 6.0 it will produce a saturated solution of some iron salt such as ferrous sulfate, but there will be combination or adsorption of some of the negative ions and the pH of the solution will be changed until the final equilibrium is on or near the curve. For most natural waters, where the prevailing dissolved compounds are bicarbonates, the pH will frequently be increased above 9.5 in the absence of dissolved oxygen. The lower curve of the figure shows the remarkable influence of dissolved oxygen tending to precipitate ferric hydroxide and to establish an equilibrium at a very much lower pH. A certain concentration of negative ions which will give 10 parts per million of soluble Fe at a pH of about 6.9 in the presence of metallic iron and the absence of dissolved oxygen will have the negative ions set free as an acid when dissolved oxygen is present, throwing the pH down towards the lower curve.

When a coating of iron rust has formed diffusion rates from the metal surface to the outside solution largely determine corrosion rates, and the concentration of soluble salts within the coating greatly influences the rate at which iron will diffuse outside of the rust. Should the solution within a film of iron rust have a pH of 9.0, which according to the curve allows a concentration of only 0.1 part per million of soluble iron; and that within another layer of rust have a pH of 6.5, which allows a concentration of several hundred parts per million of soluble iron; it seems evident that iron will be transferred much more rapidly to the outer surface in the latter case. There are other factors, however, which might not allow the transfer to be so rapid as solubility concentrations indicate.

TENDENCY FOR IRON TO GO INTO SOLUTION

It has been shown that iron has a certain tendency to go into solution with the formation of ions. When in solution these ions develop

what might be called a pressure in the opposite direction tending to resist more going into solution. If the solution pressure of the iron and the opposite pressure due to concentration become equal, solubility equilibrium has been reached. With some metals such as zinc, and probably aluminum, the solution pressure is so great that precipitation of the hydroxides and the liberation of hydrogen gas as bubbles takes place, even in pure water, and corrosion progresses slowly in the absence of oxygen. This will continue indefinitely or until the precipitate forms an impervious coating. In the case of

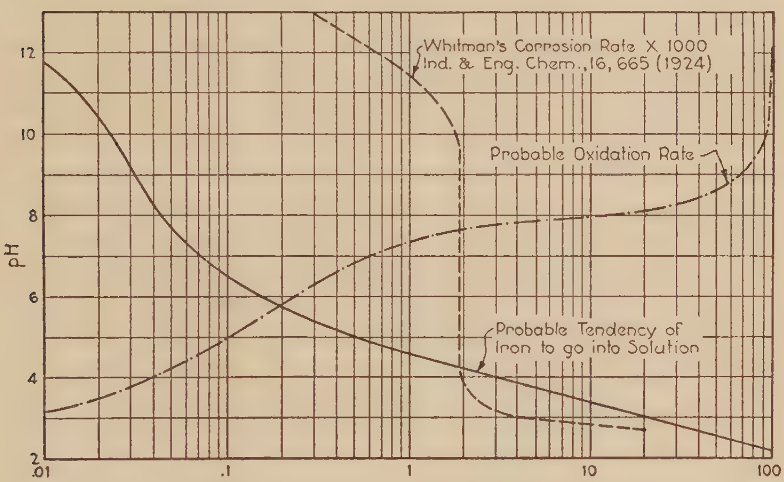


FIG. 2. EFFECT OF pH ON THE TENDENCY OF IRON TO GO INTO SOLUTION AND THE TENDENCY OF SOLUBLE IRON TO OXIDISE

Whitman's corrosion rate is penetration in inches per year per cubic centimeter of oxygen per liter.

iron, with a slightly less solution pressure, it appears that it will not corrode indefinitely in pure water in the absence of oxygen at ordinary room temperature, and probably much higher. The effect of temperature, moreover, is to increase corrosion and a point may be reached where it will continue indefinitely by the liberation of hydrogen gas. There is also a probability that the stopping of corrosion is due to the quick formation of a very thin film of iron rust which aids in reducing the solution pressure.

The factor of greatest importance in determining the tendency of iron to go into solution is the hydrogen-ion concentration of the

solution adjoining the metal surface. It has not been possible to tell if the tendency is in direct proportion to the concentration of hydrogen ions, and it may deviate at an increasing rate as the hydrogen ions increase. The curve showing the solution tendency in figure 2 is only problematical and the correct one may vary considerably from the one shown, but it is at least in the right direction. Due to so many factors tending to make the establishment of an exact curve very difficult, accurate figures are not available. Having been asked only recently by several water works chemists if corrosion does not stop when no free carbonic acid is present in the water, it might be well to emphasize that this is not the case. Iron does not stop going into solution when a fresh surface is exposed until a pH of 12.0 is passed, if the alkali is calcium hydroxide or some alkaline calcium salt. It might be mentioned that the pH of a saturated solution of calcium hydroxide is less than 13.0. Iron, however, becomes passive quite rapidly in a very alkaline solution and corrosion soon ceases, or practically ceases, giving the impression that iron is insoluble at a pH much lower than is really the case, if a fresh surface was kept exposed.

The concentration of hydrogen ions in a calcium hydroxide solution having a pH of 12.0 are quite low, for a large number of the hydrogen ions which would exist in a neutral solution have been replaced with calcium (Ca^{++}) ions. Iron cannot replace calcium ions, and as not many hydrogen (H^+) ions are present, the saturation equilibrium of the Fe tending to replace the hydrogen ions is not great at this pH. When the solution is completely saturated with calcium hydroxide it is likely that very few Fe ions can remain in solution, but as the calcium hydroxide is decreased the dissociated Ca^{++} ions also begin to decrease, and give room for more Fe^{++} ions to go into solution. It is not wise to make the statement that any metal above iron in the electromotive series, such as zinc, will replace and nearly prevent ferrous ions going into solution, even though the tendency is in this direction, but one so highly dissociated as calcium will almost, if not entirely. As the hydrogen ions increase in the solution the tendency is for the Fe^{++} ions to increase. There are, of course, so many factors affecting the actual rate of solution of iron that corrosion rates cannot be predicted on the basis of hydrogen-ion concentration, but the tendency for it to go into solution when the metal surface is exposed would be a function of the hydrogen-ion concentration, if there were quick displacement of the solu-

tion adjoining the metal and no tendency to form a surface coating. It may not be in a direct ratio, but no one doubts that the increase in solubility is in the direction of an increase in the hydrogen ions.

The significant fact from the standpoint of corrosion is that the solution of iron, when fresh surfaces are exposed, does not stop at a pH of 8.0 or a pH of 9.0, or at any pH to which it is practical to to treat the water of our public water supplies. That a change in pH of from 6.0 to 8.0 does not materially affect corrosion rates when fresh metal surfaces are exposed seems evident when all factors are considered. In fact several authors such as Speller[6] and Whitman, Russell and Altieri[7] find no material variations in corrosion rates under such conditions at a pH of from 5.0 to 9.5. The experiments of these authors were conducted under conditions of exposure different from what is likely to be the case in actual practice, and, while they are of great value in establishing certain facts, they give very little information as to what to expect in actual practice.

FACTORS INFLUENCING THE CORROSION OF IRON

For natural waters at ordinary temperatures with pH values between 6.0 and 9.0 the greatest factor causing corrosion to continue after a film of iron rust has formed is negative ions other than the OH^- ions and the force causing them to concentrate against the metal surface. Dissolved oxygen plays a very important part in precipitating iron rust, which is the cathodic material necessary for concentrating the negative ions, yet iron submerged in pure water containing only dissolved oxygen soon becomes very passive. It is the presence of both negative ions and dissolved oxygen, neither of which in ordinary waters produce rapid corrosion alone, that produces conditions most favorable for the rapid destruction of iron. Probably equal stress should be placed upon both. This, of course, assumes that the negative ions in the water are from neutral or nearly neutral salts. Since only a fairly narrow range of the entire pH scale is found in most natural waters the pH becomes first in importance only in the formation of protective coatings. This does not mean that the pH against the metal surface is not of great importance, but since it might be quite different from that in the surrounding solution the factors causing this difference may be of greater importance.

[6] Speller, Ind. and Eng. Chem., 17, 339 (1925).
[7] Whitman, Russell and Altieri, Ind. and Eng. Chem., 16, 665 (1924).

Any factor producing conditions tending to keep the metal surface exposed aids corrosion. In the formation of a coating of iron rust the porosity of the rust greatly affects the rate of diffusion from the metal surface to the outside. Alkaline solutions tend to form a more compact rust than slightly acid solutions. The natural tendency for iron to go into solution is so great at the pH values of our natural waters that it might be said that the life of iron pipe depends almost entirely upon the factors tending to retard corrosion. The greatest factor in this case is film formation. Anything tending to produce an impervious film aids in retarding corrosion. Suspended matter in the water frequently has an influence, especially if it is deposited in a fairly compact film against the metal surface. Ferric hydroxide is an excellent coagulant for the removal of suspended matter from water, and the precipitate so formed is apparently much more compact than if ferric hydroxide alone is precipitated. The natural tendency of iron rust is to form quite porous, except the membranes over tubercles, and the mixture of foreign matter such as silt or clay frequently materially affects the porosity. Biological growths may affect corrosion rates either way, and while much of the so-called iron bacteria are nothing more than growths of iron fibers, there are many instances where biological growths are present. Temperature is a factor influencing solution and diffusion rates, and it may have some influence upon the character of the rust formed.

It will be shown that the real problem in pipe protection is film formation. When we consider that iron is a soluble metal the importance of an impervious film for complete protection becomes apparent.

PITTING AND TUBERCULATION

In a recent article[8] the writer gave considerable space to causes for pits with overlying tubercles. The matter is of such great importance that a summary of the essential facts should be included here. The destruction of practically all water pipes is by pits, and any one who has repaired iron water pipes is no doubt impressed by the fact that holes are eaten through the metal almost as though they were drilled. Upon examination of the balance of the pipe it may be found to be perfectly sound and practically free from corrosion.

[8] Baylis, Ind. and Eng. Chem., 18, April, 1926.

That there is some unusual concentration of factors influencing the corrosion in spots is evident. In order to throw some light upon the reasons, many pits with overlying tubercles under all stages of formation have been examined. Only two constituents of the water has been found to be essential—dissolved oxygen and negative ions such as sulfates and chlorides. It, of course, is essential that the pH be not too low or too high, but it may extend somewhat beyond the ranges of most of our natural waters.

The examination of a large number of tubercles exposed to the Baltimore water, and a few from other waters, indicate that the sulfate ions are the ones most prevalent. If negative ions other than sulfates or chlorides can produce tubercles, they have not been found in large quantities in the tubercles examined. The carbonates, sulfates and chlorides constitute by far the majority of the soluble compounds found in most natural waters. Ferrous carbonate is so insoluble and the carbonate is so easily replaced by sulfate or chlorine ions that it is likely the presence of carbonates has very little influence on pitting if other ions are present. Ferrous carbonate is nearly insoluble at a pH of 8.0 or above, and when we consider that iron submerged in most natural waters having free CO_2 will finally reach an equilibrium with a pH above 8.0, it indicates that this ion alone probably will not cause typical pits with overlying tubercles. There are other essential conditions such as the production of iron rust which is cathodic to metallic iron, and the potential difference between this material and the iron must be sufficient to concentrate the ions of the salts in solution near the respective surfaces. These conditions are produced by corroding iron and no constituent of the water other than dissolved oxygen and negative ions of the proper kind are required. Other materials influence the results—some aiding and some retarding—but they are not essentials.

As a rule, all iron pipes are painted, galvanized, or have a coating of mill scale, consequently corrosion is usually localized at breaks in the coating. The early stages of corrosion, when a fresh surface of iron is exposed, are shown in figure 3. When iron salts begin to concentrate and form pits with overlying tubercles several stages of the progress are shown in figure 4. One characteristic of the iron rust so formed is that it is quite magnetic, and the building up of the rust on the metal is not by chance, but by a well applied force. Certain compounds of iron are probably more magnetic than others,

but it appears that all oxides of iron are attracted with some force. The unfortunate part is that this force, until a certain stage has been reached, tends to build up a very porous deposit and allows fairly rapid diffusion of the soluble compounds to the outside.

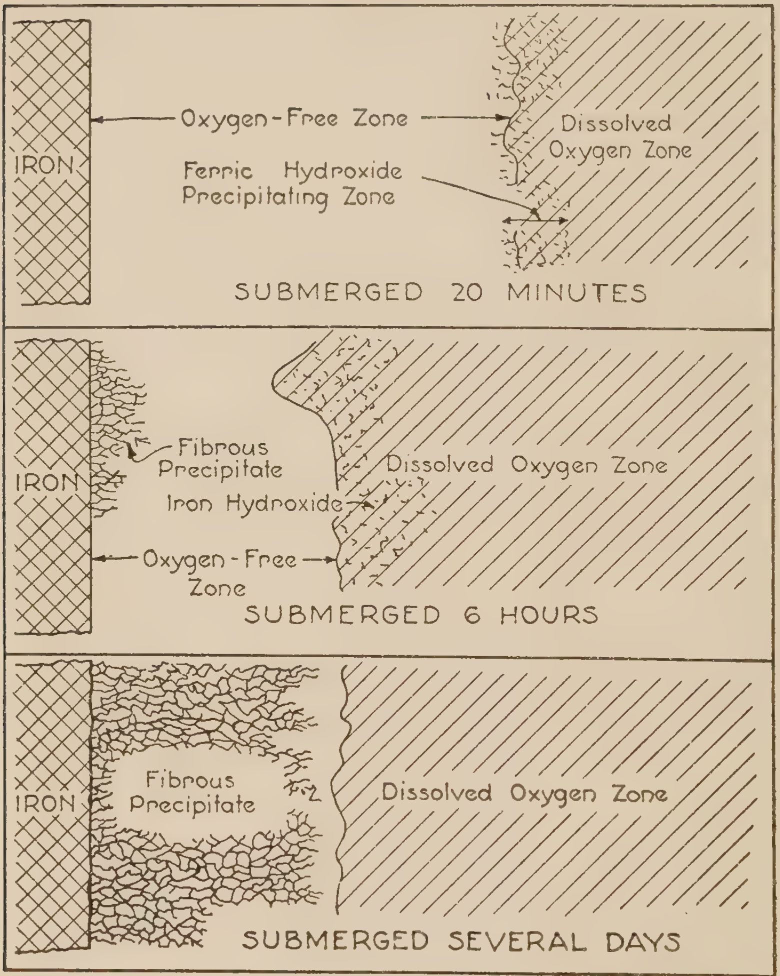


Fig. 3. First Stages of Corrosion—The Manner in Which the Precipitated Compounds of Iron Adhere to an Iron Surface

Iron is going into solution at the metal surface, combining with some negative ion present which has been drawn there by the dif-

ference in electrical potential of the metal and water. Then the nearly neutral salt diffuses through the porous deposit of iron rust to the water outside containing dissolved oxygen. Within the

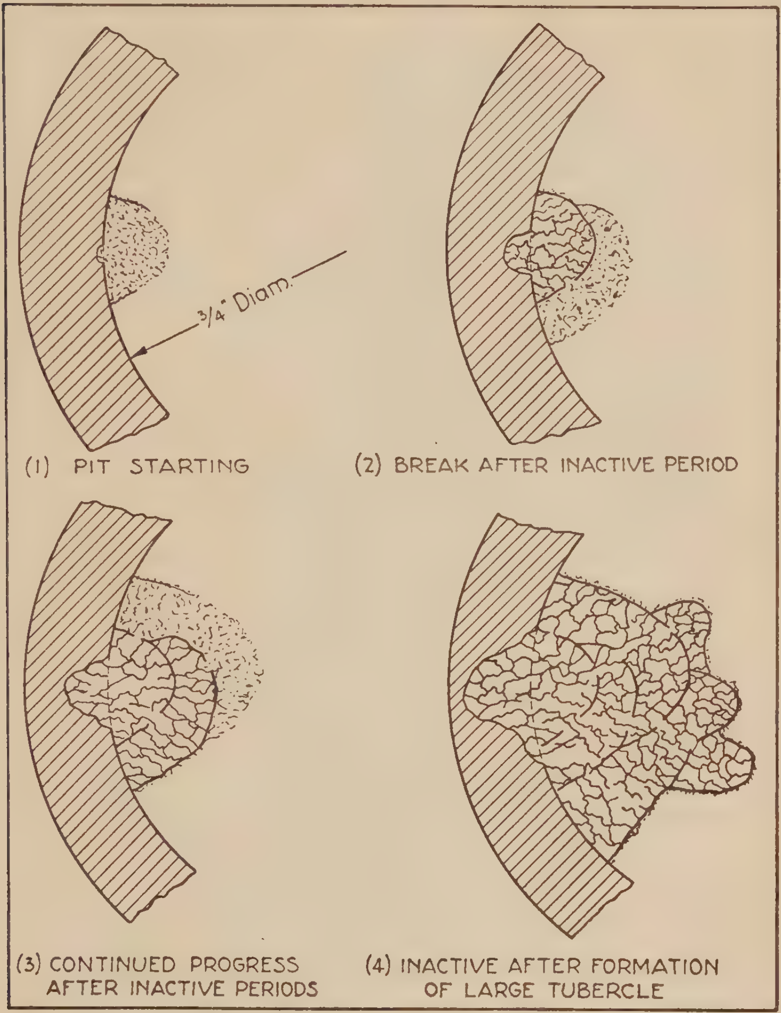


FIG. 4. THE FORMATION OF PITS WITH OVERLYING TUBERCLES IN A $\frac{3}{4}$-INCH PIPE

deposit of rust it is in oxygen-free water, but on reaching the dissolved oxygen zone ferric hydroxide or some hydrous oxide of iron is formed. This is much less soluble and precipitates at a much

lower pH than ferrous hydroxide. The formation of the insoluble precipitate releases negative ions formerly in combination and causes an increase in the hydrogen ions. This might not be so serious if

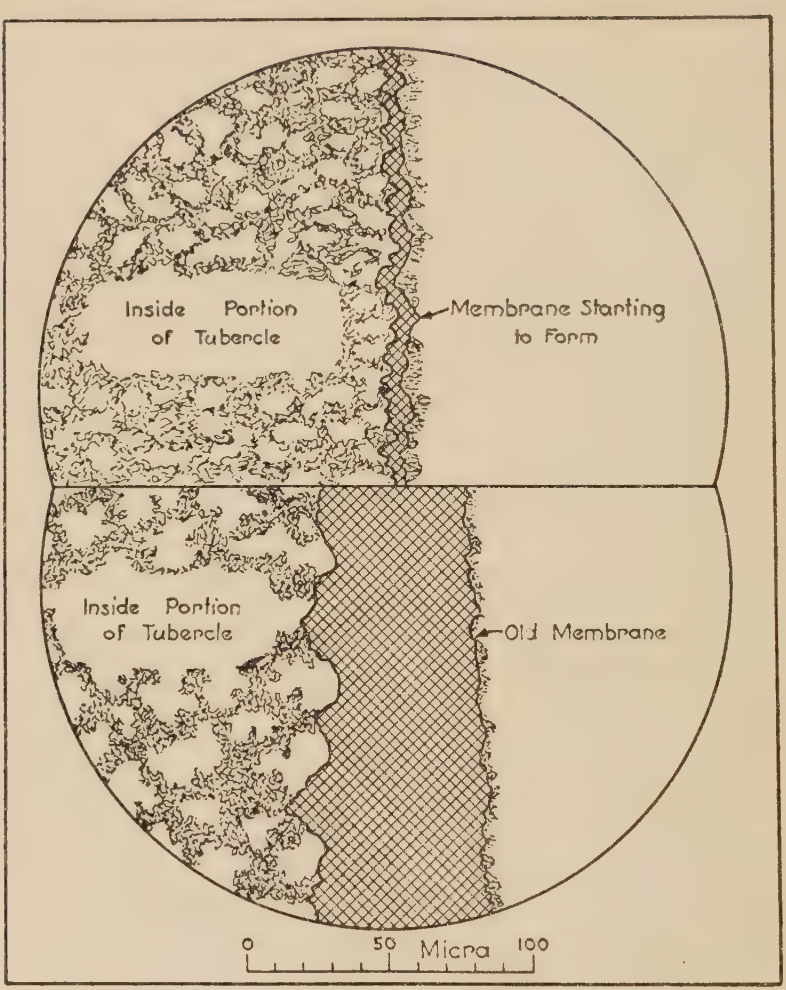


FIG. 5. MEMBRANE FORMATION AT THE SURFACE OF TUBERCLES

The membrane is a crystalline compound of iron which is quite magnetic, and eventually forms an impervious membrane over the tubercle.

the negative ions released diffused away from the surface into the water, but this is not the case. The difference in electrical potential

sends them back towards the metal surface to repeat the cycle. As the coating of rust becomes thicker a longer time is required for the salts to diffuse out, and a point is soon reached when the dissolved oxygen zone extends to the surface of the rust. The precipitation then begins to take place within, but very near the surface of the coating of rust. This forms an impervious or nearly impervious membrane, as shown in figure 5, but corrosion continues until considerable iron oxide has been precipitated. Well defined membranes only 5 micra in thickness have been observed, whereas the membrane

TABLE 1

Soluble compounds extracted from tubercles on inside of cast iron pipe

SOLUTION WITHDRAWN	DAYS STANDING	pH	SOLUBLE IRON (Fe)	Fe_2O_3	Mn	CHLORIDES (Cl)	CaO	SULFATES (SO_4)
cc.			*p.p.m.*	*grams*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*grams*
400	0.1	3.0	560	0.352	20	65	40	0.425
400	1	2.9	600	0.358	10	50	24	0.433
450	2	3.1	320	0.212	5	25	Trace	0.257
400	7	3.5	300	0.195	3	15	Trace	0.218
400	11	3.4	340	0.182	3	11		0.295
400	9	3.5	200	0.143	2	10		0.163
475	19	3.5	160	0.129	Trace	9		0.143
480	13	3.2	60	0.064		8		0.055
Total........................				1.635				1.989

One hundred thirty grams of wet tubercles from the inside of a 10-inch water pipe. The rust was submerged in distilled water in an open beaker. Most of the solution was withdrawn at various intervals and replaced with distilled water.

The total amount of sulfates extracted amounts to 1.53 per cent of the total weight of the wet tubercles. This means that the solution within the tubercle must have had a concentration of 4 or 5 per cent ferrous sulfate ($FeSO_4$).

over dormant tubercles are very much thicker, usually from 20 to 75 micra in thickness. During the process of membrane formation negative ions such as the sulfate and chloride ions are being concentrated between the membrane and the iron surface, and results in the formation of considerable ferrous salts. There is a possibility that the iron precipitated in this film is a certain oxide of iron essential to the concentration of negative ions, and that other oxides of iron will not cause them to concentrate. Unless suspended matter such as silt or clay has been deposited with the iron rust the inside portion of the tubercle between the membrane and the iron sur-

face becomes very porous, probably by a re-precipitation of the hydrous oxides of iron, and allows rapid diffusion of soluble salts through this portion of the tubercle. When the membrane becomes impervious the pit is dormant and the salts within the tubercle reach solubility equilibrium. The pH of the inside solution is then between about 6.4 and 6.8, depending upon the concentration of iron salts and other soluble compounds. It is possible to conceive of conditions where the pH of the inside solution of dormant tubercles is above 7.0, but for the vast majority it is believed to be within the ranges given. For corrosion to take place the pH must be below equilibrium. A number of tests indicate that the pH of active tubercles is near 6.0. However, there are conditions where this may fluctuate somewhat. The pH at least has to be slightly lower than it is at solubility equilibrium.

Much depends upon the impervious membrane formed over tubercles as to the amount of corrosion which will take place. Should the membrane be formed so toughly that it never breaks there will be complete stoppage of corrosion in the underlying pit. The character of the water, that is the pH and soluble constituents of the water, have considerable influence on the toughness of the membrane formed. Very alkaline waters may build a membrane that never breaks, whereas with fairly acid waters the breaks may be frequent. The slowness of oxidation and precipitation rates probably is one reason why slightly acid waters do not build so tough a membrane. Part of the soluble iron diffuses away from the point where corrosion is taking place into the main body of the water in the pipes, and if the water is flowing the soluble iron may be carried some distance from the point where corrosion is taking place before finally being precipitated. The precipitation is then extended more or less over the entire surface and not in spots as is the case with more alkaline waters. If a tubercle is under the process of healing a break by forming the impervious membrane at the surface where dissolved oxygen is present, and more rust is precipitated over the surface, cutting off the dissolved oxygen, membrane formation is stopped at this point. The formation of another membrane then has to start anew, probably only again to be covered with the rust before it becomes impervious.

CORROSION OF ZINC

There is every indication that zinc corrodes in the same general manner as iron, and, having a greater solution pressure, corrosion

will continue in the absence of oxygen to the point of liberating hydrogen gas bubbles. That is, zinc will continue to corrode merely by the liberation of hydrogen gas so long as the metal surface is exposed. Fortunately the oxides or hydroxides of zinc build up quite compactly on the metal surface, and if it were not due to this

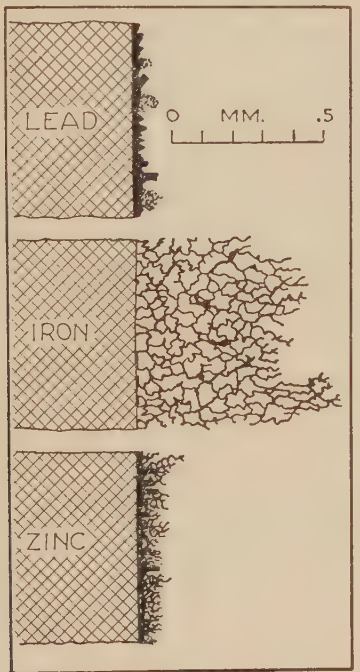


FIG. 6. CHARACTERISTIC PRECIPITATES ON METAL SURFACES AFTER BEING EXPOSED TO WATER FOR SEVERAL DAYS

Note the very compact and partially crystalline precipitates on the surfaces of lead and zinc as compared with the porous precipitate on iron. In many instances the precipitate on iron is much more compact than is shown, but such porous precipitates are frequently found. When zinc is exposed to most natural waters there is at first a precipitate of zinc oxide or hydroxide which is formed quite rapidly, but upon standing several days crystalline compounds almost completely cover the surface.

factor the life of zinc exposed to water would be short. A comparison of the precipitates of zinc, iron and lead compounds are shown in figure 6. It will be noted that the iron precipitate is frequently quite porous, whereas zinc and lead form a tough and very com-

pact precipitate. After standing for a few days the precipitate next to the metal surface becomes crystalline. With zinc it is probably a crystalline zinc hydroxide. Approximate solubility has been determined, and appears to be a curve closely following the one for

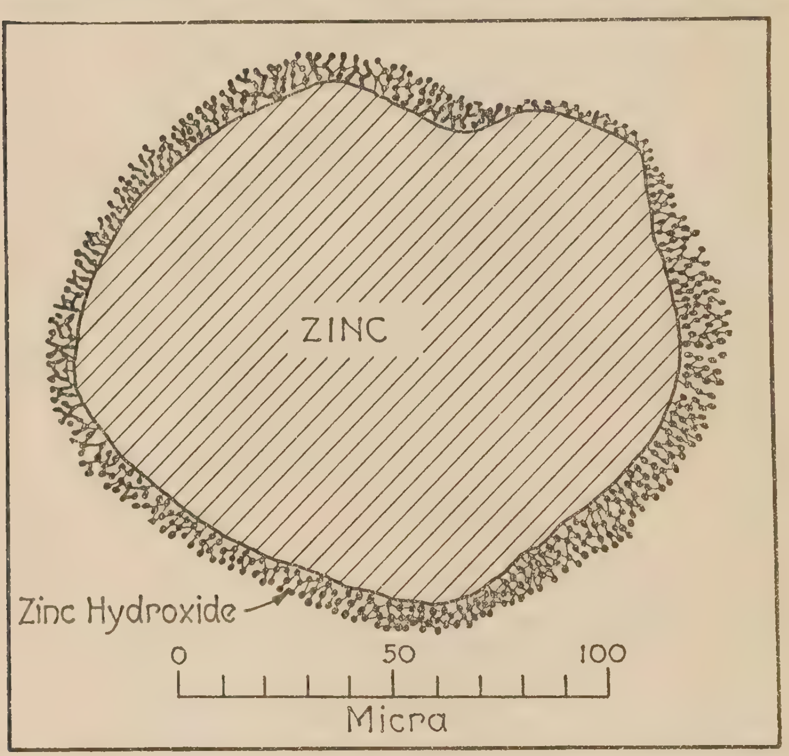


FIG. 7. METALLIC ZINC IS SLIGHTLY SOLUBLE IN WATER, POSSIBLY FIRST FORMING A HYDROXIDE, WHICH IS INSOLUBLE

The precipitation appears to be very rapid as most of the metal going into solution is precipitated on the zinc or other nearby surfaces. It forms a very tough membrane, which probably is eventually composed of both the hydroxide and carbonate. This coating offers almost complete protection to the metal in most natural waters.

iron. This is shown in figure 8. There are indications that it is just a little lower than the iron curve in the absence of oxygen. Due to the difficulty in making zinc determinations when present in small quantities the amount shown may be slightly in error. More accurate figures, however, will not shift the curve materially. A

pH of 6.5 apparently is the critical pH for zinc, and any natural water below this pH very likely will corrode zinc readily. The quickness with which zinc builds up an impervious coating in alkaline

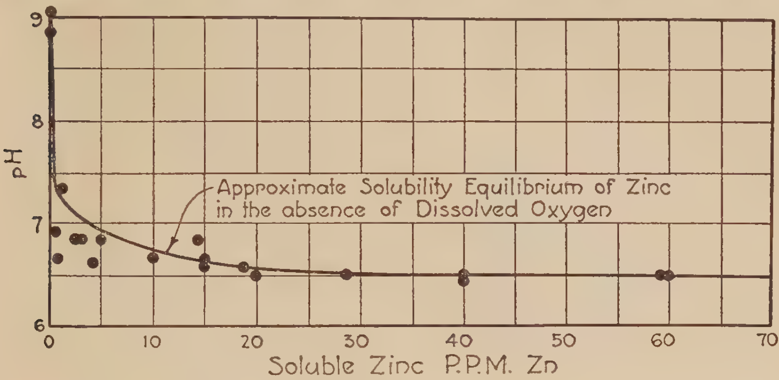


FIG. 8. RELATION OF pH TO THE SOLUBILITY OF ZINC

solutions makes the determination of true solubility equilibria more difficult than for iron.

Zinc apparently does not form pits with overlying tubercles as is

TABLE 2

Liberation of hydrogen gas by zinc metal in the absence of oxygen

TIME STANDING	TEMPERATURE	HYDROGEN GAS PER TWENTY-FOUR HOURS
days	*°C.*	*cc.*
2	20	1.6
7	20	1.4
17	19	1.1
24	21	1.5
25	20	1.0
26	38	4.5
34	38.5	3.2
35	36.5	2.0
38	36	1.9
45	37	2.0

Fifty grams of 20-mesh pure zinc metal were placed into a 500 cc. flask and filled with freshly boiled and evacuated distilled water. The flask was tightly stoppered with no air space, but contained a device projecting through the stopper for accurately measuring the liberated hydrogen gas.

the case with iron. This may be accounted for in two ways. Iron does not ordinarily produce ferrous hydroxide to the extent of pro-

TABLE 3

Solubility equilibrium of zinc in the presence of zinc sulfate

ADDED N/1 H_2SO_4	TIME STANDING	pH	SOLUBLE Zn
cc.			*p.p.m.*
2	15 minutes	4.0	
	3½ hours	6.0	
	2 days	6.5	60.0
2	2 minutes	3.7	
	2 hours	5.6	80.0
	24 hours	6.5	
	4 days	6.5	
	5 days	6.5	
	8 days	6.5	
	15 days	6.4+	50.0
	30 days	6.5−	
	39 days	6.5	
	54 days	6.5	
	70 days	6.6	18.0
	85 days	6.6+	1.0
5	5 minutes	4.8	
	20 minutes	6.2	
	18 hours	6.5	80.0
	3 days	6.5	
10	1 minute	2.8	
	5 minutes	3.0	
	10 minutes	3.8	
	15 minutes	4.6	
	20 minutes	5.8	
	25 minutes	5.9	
	30 minutes	6.0	
	40 minutes	6.2+	
	1 hour	6.4	
	1½ hours	6.4+	200.0
	2 days	6.5	175.0
	4 days	6.5	
	19 days	6.5	

Two hundred grams of pure zinc metal were placed into a 2,000 cc. flask, the flask filled with distilled water, and certain quantities of sulfuric acid added. For making the pH tests 5 cc. of the solution was removed, each time and for making the zinc tests 25 cc. was removed. The solution withdrawn was replaced with distilled water.

ducing a precipitate, consequently the soluble iron usually diffuses out to the surface of the rust, or into the main body of the water before being precipitated, and the building up of the rust which is largely by magnetic attraction is porous. Zinc will form a precipitate beneath the oxide or hydroxide already formed tending to make the deposit more compact. This tendency to compact and to form a crystalline precipitate aids in preventing a great concentration of negative ions, even though the tendency may be to concentrate.

TABLE 4

Hard spring water in contact with lead

TIME STANDING	pH	ALKALINITY	
		Phenolphthalein	Methyl orange
0 minutes	7.0	0	188
5 minutes	7.5		
10 minutes	7.8		
15 minutes	8.0		
20 minutes	8.2		
30 minutes	8.6	12	176
60 minutes	8.7	12	164
2½ hours	8.8	16	132
4 hours	9.0		
6 hours	9.5	24	104
7½ hours	9.6	24	92
24 hours	Over 9.6	32	80
32 hours	Over 9.6	32	76
2 days	Over 9.6	36	64
3 days	Over 9.6	120	160

One hundred twelve grams of commercial lead wool submerged in 300 cc. of hard spring water having a pH of 7.0, CO_2 23.8 and alkalinity 188. The water was agitated almost continuously for thirty minutes and then occasionally for the balance of the time.

There is a possibility that the difference in electrical potential of the metal and the precipitate is not great enough to concentrate ions. Zinc being bivalent only, the equilibrium of the salts in the presence of dissolved oxygen is at a much higher pH than for the iron salts.

The fact that it is better to try to protect the protective coatings on iron than to protect the iron itself, makes the problem of zinc protection of great importance. As the treatment recommended for the protection of iron will also protect zinc, the matter will be discussed more fully in another paragraph.

CORROSION OF LEAD

Even though lead is just above hydrogen in the electromotive series, it corrodes fairly rapidly when fresh surfaces are exposed, especially when CO_2 is present. Like zinc, it quickly forms an impervious coating either of oxide or carbonate of lead, probably both in many instances. The precipitate in most natural waters containing free and half-bound carbonic acid is distinctly crystalline, and the compound may be a basic carbonate of lead, $Pb_3(OH)_2(CO_3)_2$. It is not known whether there is an acid carbonate of lead or not, but the amount of lead found in solution in waters containing considerable free CO_2 indicates there may be a more acid and more

TABLE 5

Rapid reduction of CO_2 in water exposed to lead

TIME STANDING	pH	ALKALINITY		
		Phenolphthalein	Methyl orange	CO_2
0 minutes	5.8	0	52	154.0
10 minutes	6.0			
30 minutes	6.2			
$1\frac{1}{2}$ hours	6.4			
4 hours	6.6	0	96	21.1
24 hours	9.0			0
48 hours	9.2	8	64	0

One hundred grams of lead wool submerged in 325 cc. of the Baltimore water highly carbonated. The water was gently agitated occasionally, but not enough to release any of the CO_2. Similar treatment of a sample of the carbonated water without the lead wool showed very little loss of CO_2.

soluble compound. The coating on a lead surface builds up rapidly and it is somewhat like zinc and aluminum in that true solubility concentrations are difficult to establish. It might be said that lead is satisfactory from the standpoint of corrosion for use in all water where the pH is between 7.0 and 9.5. It also has a very long life in water of a lower pH, but the possibilities of lead poisoning should be taken into consideration.

BRASS AND COPPER PIPE

Copper and high-copper brass ("red brass") pipes are so resistant to corrosion in all natural waters that it has not been possible to form much idea of their life. Such pipe probably will be satisfactory

for almost all uses in natural waters. So long as the price is within reasonable bounds the use of such pipe may be extended with profit in some localities. It is not believed that there is enough copper available to warrant the hope that all pipes can be changed to this material. Unless there is enough to replace all pipes both large and small throughout the distribution system the water department would still be confronted with the problem of corrosion of any iron pipes which may be in the system. A general use of high-copper pipes for household laterals may be advisable in some instances, but where there is considerable corrosion of the mains such pipes may be stopped up with deposits of iron rust. In other words brass

TABLE 6

Water in contact with brass lathe turnings

APPLIED WATER		TIME STANDING	AFTER STANDING IN CONTACT WITH BRASS		
			pH	Alkalinity	
pH	Alkalinity			Phenolphthalein	Methyl orange
6.7	27	20 minutes	9.6+	7	27
6.7	27	10 minutes	9.6+	8	27
6.8	200	2 days	9.6+	7	49
6.9	120	1 day	8.6	3	44
7.9	36	4 days	8.7	3	34
6.6	23	1 day	7.6	2	26
6.6	24	3 days	8.4	1	33
6.4	26	3 days	8.7	4	33
6.5	26	4 days	8.5	2	35

About 40 grams of lathe turnings from a soft brass bar were placed into pyrex flask and about 200 cc. of water added for each test. The water was occasionally agitated.

or copper will not completely eliminate clogging of service pipes when the mains are being corroded. The writer has seen many lead pipes stopped up from such causes, and copper will not be immune under such conditions, though it may not clog so rapidly as lead pipes. Table 6 shows that brass pipe has the same tendency to remove the carbonate ions from water as iron or zinc when fresh surfaces are exposed, but a film is soon formed and there will be very little corrosion taking place.

CONCRETE AND CEMENT LINED PIPES

Someone recently suggested to the writer that, if the cast iron mains were all cement lined and all laterals were brass pipe, the problem of deterioration would be solved. It is admitted that this would greatly lengthen the life of some of our distribution systems, but a warning should be given that cement is not so durable as many believe it to be when exposed to slightly acid water, especially water having considerable sulfates. Over 90 per cent of the calcium in portland cement may be extracted when the water is corrosive to calcium carbonate. It is true the process is very slow. Nevertheless it is gradually taking place. It is now the opinion of certain chemists engaged in research work on cement that the high-calcium silicate compounds of cement gradually break down to a compound of lower calcium content when submerged and give off calcium hydroxide to the extent of forming calcium hydroxide crystals. The writer is not prepared to accept such an opinion at present, but, from a number of extraction tests conducted on various samples of concrete, it is evident that the cement compounds do give off calcium hydroxide at a gradually decreasing calcium solubility concentration until practically all the calcium is removed, if the water is corrosive to calcium carbonate. This may be illustrated by taking a sample of old concrete from within the interior of a piece of good sound concrete, pulverizing, and then submerging in a tightly stoppered flask with distilled water. If a sample containing about 10 grams of CaO is used the amount of calcium hydroxide going into solution may be approximately calcium hydroxide saturation. If most of the solution is removed and more distilled water added the concentration of calcium hydroxide will be less than in the previous solution. Repeating the extraction, practically all calcium can be removed from the concrete. Each time the amount of calcium hydroxide concentration is less than in the previous solution removed.

The danger point in concrete is frequently when part of the calcium has been removed. When it has been removed to the point where the solubility equilibrium is about one-half the saturation point of calcium hydroxide the aluminum compounds begin to go into solution. This may cause a change in the chemical composition of a large portion of the cement compounds. This is especially true when exposed to waters high in sulfates. Calcium sulfo-alumi-

nate may be formed, which is a compound that not only does not add strength to the concrete but greatly weakens it. Cement lined pipes are all right, and their use probably should be more general, but when the water is slightly acid there will be a gradual deterioration of the cement. This does not mean that cement, when a coating of sufficient thickness is used, will not add greatly to the life of cast iron pipe under such conditions. It is probably the most durable coating that can be used, but it is not a cure for all evils. Cement lined pipe, with water treated to calcium carbonate equilibrium, will have a very long life. Such pipe under this condition probably will never fail by corrosion from the inside, unless the lining becomes broken loose. The point the writer wishes to make is that, even though cement lined pipes are used, it will still be economy to treat the water to approximately calcium carbonate equilibrium.

TREATMENT OF WATER TO PREVENT CORROSION AND "RED WATER"

All efforts to find suitable pipe materials at a cheap price which are non-corrosive to slightly acid waters have failed. Should such a material now be found we are confronted with the fact that there are nearly two billion dollars worth of iron pipes in use throughout the world. No one believes that all this pipe would be replaced, even though a durable substitute should be found which costs no more than the present iron pipe. Regardless of what the future may bring forth in pipe materials, and the writer certainly does not wish to discourage research along this line; we are confronted with the problem of protecting existing pipes in the majority of our cities. In some localities the water is not corrosive and there is good protection, but in others the need is urgent. Serious corrosion is taking place in over one-half of our distribution systems. Since it has been shown that iron and zinc are slightly soluble in natural waters, the problem becomes one of protection by film formation, for it is neither practical or desirable to remove the dissolved oxygen from an entire water supply. In fact the corrosion of zinc is not dependent upon dissolved oxygen, but its presence no doubt hastens the reaction when a fresh surface is exposed. Impervious films must be formed which will prevent diffusion of soluble iron or zinc from the metal surface to the outside water. These films may be formed by precipitating the products of corrosion on the metal surface, or by producng a supersaturation of some compound in the water such as calcium carbonate which will form an impervious coating.

Films produced by the products of corrosion

It has been shown that there is no ordinary compound of iron which will exist in solution in most waters in quantities greater than 0.1 part per million of soluble Fe when the water is at calcium carbonate solubility equilibrium, or more alkaline, within the ranges of natural waters. When the water is at this point, or more alkaline,

TABLE 7

Rapid increase in pH caused by corroding iron

Experiment number	Applied water		pH after standing the following minutes:										Standing 40 minutes	
	Alkalinity	pH	1	2	3	4	5	10	15	20	30	40	Alkalinity	Soluble iron (Fe)
														p.p.m.
1	39	7.2	7.3	7.4	7.8	8.2	8.5		8.6					0.20
2	39	6.4	6.5	6.6	6.8	6.9	7.1	7.3	7.4	7.7	7.7			
3	39	7.2	7.3	7.3	7.4	7.9	8.3	9.0	9.4				35	Trace
4	39	7.2	7.3	7.4	7.7	7.9	8.2	9.2	9.4	9.6			35	Trace
5	39	7.2	7.3	7.3+	7.7	7.9	8.2	9.0				9.6	33	Trace
6	38	7.2	7.3	7.8	8.1	8.6	8.7	9.0	9.0		9.0		35	0.10
7	38	7.2	7.3	7.7	8.2	8.6	8.8	9.0	9.1	9.2	9.3		32	Trace
8	39	7.2	7.3	7.3	7.3	7.3	7.3	7.3+	7.4	7.7	7.9	8.0	30	0.15
9	39	7.2	7.4	7.8	8.0	8.6	8.7	9.0	9.2	9.2	9.0		25	0.10

About 75 grams of lathe turnings from a black wrought iron pipe were placed into a flask, the flask nearly filled with the water to be tested, and then stoppered. The water was kept agitated by tilting the flask almost continuously for five minutes and then occasionally for the balance of the time. Experiment 1 was started with lathe turnings which has been treated with sulfuric acid and washed several times to make nearly free from the acid. After each test to no. 7, the water was all poured out and the lathe turnings allowed to stand exposed to the air while wet for several minutes. New iron lathe turnings freshly cut were used beginning with experiment 8. These experiments show that not only is all the free CO_2, but part of the half-bound is removed from the solution.

the rate of going into solution is comparatively slow and all products of corrosion where dissolved oxygen is present are quickly precipitated. It is shown by tables 7 and 8 that corroding iron usually increases the pH by removing some of the negative ions, especially the carbonates. Table 8 shows that not only is part of the half-

bound carbonic acid removed, but there is a reduction of the calcium carbonate. The corroding iron has adsorbed or combined with enough CO_2 to increase the pH above the solubility equilibrium of calcium carbonate, and has resulted in a precipitation of some of the calcium carbonate which also aids in film formation. Unfortunately, when negative ions such as the sulfates and chlorides are

TABLE 8

Reduction of CO_2 and alkalinity by corroding iron

TIME STANDING	APPLIED WATER			AFTER STANDING IN CONTACT WITH THE IRON			
	pH	Alkalinity	CO_2	pH	Alkalinity	CO_2	SOLUBLE IRON (Fe)
							p.p.m.
18 hours	6.4	34	18	7.7	36	2.0	0.2
48 hours	6.0	34	30	9.4	36	0	0.1
½ hour	6.4	35	18	7.2	35	4.5	1.0
5 days	6.5	35	15	8.6	30	0	0.1
20 hours	6.0	2	2	8.6	11	0	0.2
6 hours	7.0	72	12	9.6	52	0	Trace
24 hours	7.5	90	6	9.0	56	0	Trace
23 hours	7.2	111	12	9.4	46	0	Trace
23 hours	7.0	150	20	9.0	62	0	Trace
48 hours	7.5	180	11	9.6	40	0	Trace
48 hours	6.8	205	50	8.2	75	0	Trace
3 days	6.7	210	60	8.4	73	0	Trace
4 days	6.9	160	25	8.4	50	0	Trace
5 days	6.8	196	48	8.2	56	0	0.1
3 days	6.8	196	48	8.1	52	0	0.1
4 days	6.8	211	52	7.8	64	1.0	0.3
5 days	6.8	200	50	8.0	55	0	
2 days	6.8	188	45	7.6	72	3.2	0.3
3 days	6.9	188	40	7.8	58	0.8	0.1

About 50 grams of iron lathe turnings from a black wrought iron pipe were placed into a 250 cc. glass tube and the tube loosely stoppered. The reduction in alkalinity is due to the reduction of free and half-bound CO_2 producing a pH above the calcium carbonate solubility equilibrium curve.

present they concentrate in spots and pits and overlying tubercles are formed before the surface film becomes impervious. When water is at the solubility equilibrium of calcium carbonate, which is shown in figure 9, fairly tough membranes are formed over pits. These membranes occasionally break and allow corrosion to continue until another one is formed, but the breaks are not nearly so numerous in alkaline waters as they are in slightly acid waters.

Zinc has a greater tendency than iron to form impervious films when the pH is above 6.5, and when it is near the calcium carbonate curve the life of the galvanizing is greatly lengthened. If a fresh zinc metal surface is exposed to fairly alkaline water the first product of corrosion appears to be a gelatinous hydroxide of zinc, but on

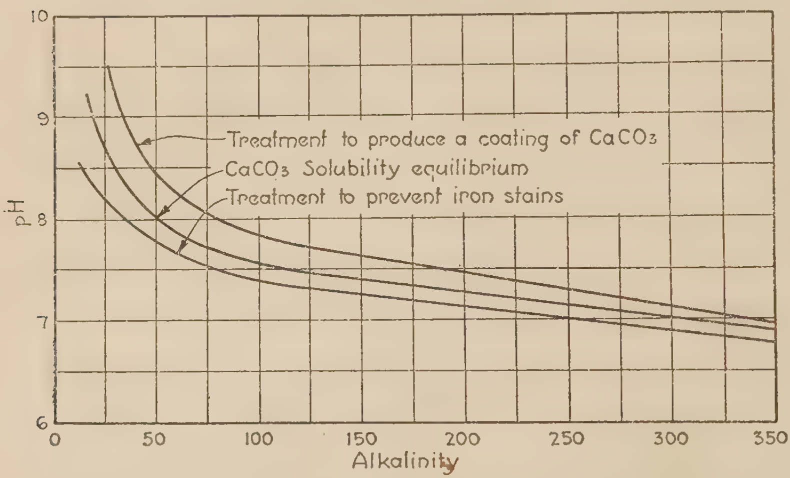


Fig. 9. Relation of pH and Alkalinity to the Proper Treatment of Water to Prevent Corrosion

The calcium carbonate solubility curve shown is based upon calcium carbonate in distilled water at 22°C. It is approximately correct for natural waters low in soluble salts, but should be checked when used on waters containing considerable dissolved compounds. If it is desired only to prevent staining of toilet fixtures, etc., and to have an occasional occurrence of "red water," the water may be treated to the lower curve. When it is desired to form a protective coating of calcium carbonate, lime should be added until the pH falls on the upper curve, or slightly higher. Calcium carbonate will then be precipitated only on solid surfaces. Should lime be added until the pH is considerably above the curve there is danger of forming a calcium carbonate precipitate throughout the solution. After a coating has been formed the water may be treated only to the calcium carbonate curve, or slightly higher.

standing a few days a crystalline precipitate builds up next to the metal surface. This was at first thought to be a carbonate of zinc, or some basic compound, but what appears to be the same type of crystal has been formed when zinc metal is submerged in distilled water made slightly acid with sulfuric acid. It is probably a crys-

talline zinc hydroxide. These crystals are not stable below a pH of about 6.4, or probably slightly lower, and this may be the main reason why galvanized iron pipes do not last very long when the pH of the water is below this point.

Iron pipe without a protective coating of zinc or some durable paint should not be exposed to any of our natural waters. It is possible to form impervious films which will eventually stop corrosion, but not until considerable tuberculation has taken place and the pipes reduced in carrying capacity. It is far better to protect the zinc on galvanized pipes and the paint or cement coating on cast iron pipes than to try to protect iron surfaces. In case it is not desired to produce a coating of calcium carbonate on the pipe surfaces, *all public water supplies should at least be treated to where very little soluble iron will exist in the water in the absence of dissolved oxygen.* When so treated there is fairly rapid healing of the breaks in tubercles and the tubercles do not grow so large as they do in more acid waters. Almost any alkali probably is suitable for this treatment, but it is better from the standpoint of corrosion to use caustic alkalies and not carbonates such as sodium carbonate. Any compound adding negative ions other than the OH^- ions to the water has a tendency to increase corrosion over what it would be if none were added. This is assuming other conditions such as pH and alkalinity are equal. Sodium carbonate is now used in some water treatment plants to increase the pH, and it may be very effective in preventing stains and may also reduce corrosion, but the compound itself does not form a precipitate and aid in film formation as is the case with calcium carbonate. It has the advantage, however, of not adding soap hardness to the water.

If it is desirable merely to prevent staining, and to reduce "red water" troubles to an occasional occurrence, the water should be adjusted to the lower curve in figure 9 with almost any suitable alkali. It should be understood that the treatment to this curve does not entirely stop corrosion, but will reduce it to where it is not serious if the pipes have good protective coatings applied by the manufacturer. In fact such a treatment will offer almost complete protection to galvanized iron, cement lines and lead pipes. There is a question as to whether treatment should be stopped at this point, or be continued to the point of producing a calcium carbonate coating, which almost completely stops corrosion. The writer is inclined to favor complete protection.

Treatment to produce a coating of calcium carbonate

Treatment of water with lime appears to be the cheapest and most effective means of protecting iron pipes on the inside. The alkaline sodium compounds are so soluble that their chief aid in preventing corrosion is to produce conditions more suitable for the precipitating or depositing of other less soluble compounds occurring in the water. The addition of sodium hydroxide or sodium carbonate to waters containing considerable calcium bicarbonate may produce a supersaturation of calcium carbonate and cause a precipitate. The amount of calcium carbonate which will be held in solution depends

TABLE ?

Loss of alkalinity by passing alkaline water through 50 feet of ¼-inch black iron pipe which has been in service eight months

Before passing pipe			Rate of flow per minute	After passing pipe		
pH	Alkalinity			pH	Alkalinity	
	Phenolphthalein	Methyl orange			Phenolphthalein	Methyl orange
			cc.			
9.5	26	51	28	9.3	20	45
9.5	28	52	22	9.3	16	44
9.4	22	50	30	9.3	16	46
9.4	26	51	33	9.3	16	45
9.5	28	52	18	9.3	20	43
9.4	29	51	12	9.2	17	42
9.6	24	50	23	9.3	16	44
9.4	26	50	20	9.1	16	43

Tests were made at various intervals during a period of eight days.

upon the alkalinity, hydrogen-ion (pH) concentration, and to a slight extent upon the amount of neutral salts present. No certain alkalinity or pH can be set as that desired for all waters. The calcium carbonate equilibrium curve in figure 9 shows that it is only by a knowledge of both pH and alkalinity that the saturation point of calcium carbonate may be estimated. The saturation or solubility equilibrium point is where the water will neither dissolve nor precipitate calcium carbonate. Water containing a large amount of certain neutral salts such as the sulfates and chlorides will give curves slightly different from the one shown. In such cases it is desirable to establish a curve for the particular water. This may be done by adding a large excess of calcium carbonate to the water and

sealing in a non-corrosive glass container for about one week. The sample should be thoroughly agitated several times daily. It

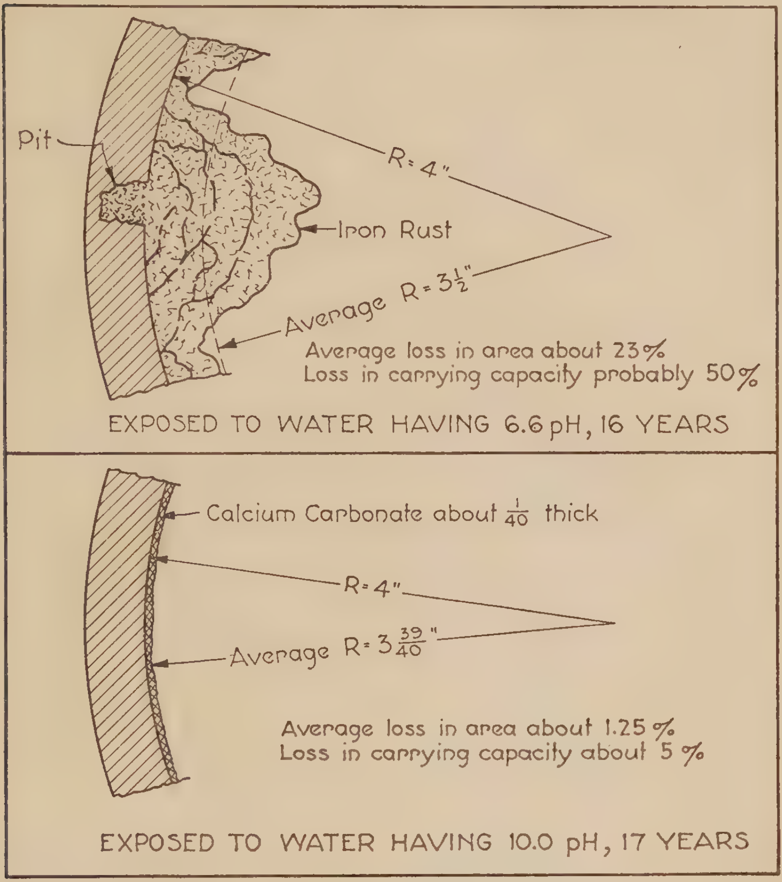


FIG. 10. SECTIONS OF CAST IRON PIPE EXPOSED TO CORROSIVE AND TO NON-CORROSIVE WATER

The drawings show typical conditions found in two fairly large cities having different characters of water. A slight adjustment of the pH of the water in the lower sketch will stop the precipitation of any additional calcium carbonate.

is impossible to apply lime intelligently to water without a knowledge of the hydrogen-ion concentration, yet it is a factor many try to ignore.

In the formation of a calcium carbonate coating it need not be

thick enough to materially reduce the carrying capacity of the pipes. The writer has seen coatings not over $\frac{1}{64}$-inch in thickness which offered almost complete protection. Almost any water softened by the addition of lime, or any water treated with sulfate of iron and lime to remove the suspended matter will form such a coating. When it is for softening the tendency will be to build up a coating too thick unless the pH is reduced. There have been a few attempts to correct this by the addition of CO_2 to the water just before filtration. This is good practice, even though additional negative ions are added, but care should be taken not to decrease the pH below calcium carbonate equilibrium. It is much better to use CO_2 than sulfates or chlorides. Water treated with sulfate of iron and lime probably comes the nearest to being adjusted to the proper treatment to prevent corrosion. In fact, with a little care in correctly controlling the pH, and with the small amount of calcium carbonate removed in the filter beds, the pH and alkalinity may be kept almost on the upper curve shown in figure 9. In some instances sulfate of iron is used when the water is softened with lime, and at such places the pH is usually just a little too high. At New Orleans, with an alkalinity of about 35 to 40 and a pH between 9.5 and 10.0, a coating of calcium carbonate less than $\frac{1}{32}$-inch in thickness has formed in seventeen years. Compare the reduction in carrying capacity in this situation as shown in figure 10 with that of conditions found in another city having a fairly corrosive water. It is evident that the treatment at New Orleans is the more desirable of the two, especially when the New Orleans coating may be easily prevented from building up any thicker by a slight adjustment of the pH of the filtered water.

THE EFFECT OF CLEANING CAST IRON MAINS IN CORROSION

Where there is serious tuberculation of cast iron mains their carrying capacity is frequently reduced over 50 per cent, or to a point where an adequate supply of water cannot be furnished in case of a fire. In such instances it is necessary either to clean the existing mains, or to lay new ones. The customary procedure in cleaning water pipes is to run some kind of a device through them which will knock loose the tubercles. When done efficiently the original carrying capacity of the mains may be nearly restored immediately after cleaning. After such cleaning will the rate of tubercle formation and clogging be faster than originally? Every evi-

dence points to the fact that it will be. The writer has been informed by several water works superintendents who have had part of their mains cleaned, where the water is fairly corrosive, that it is

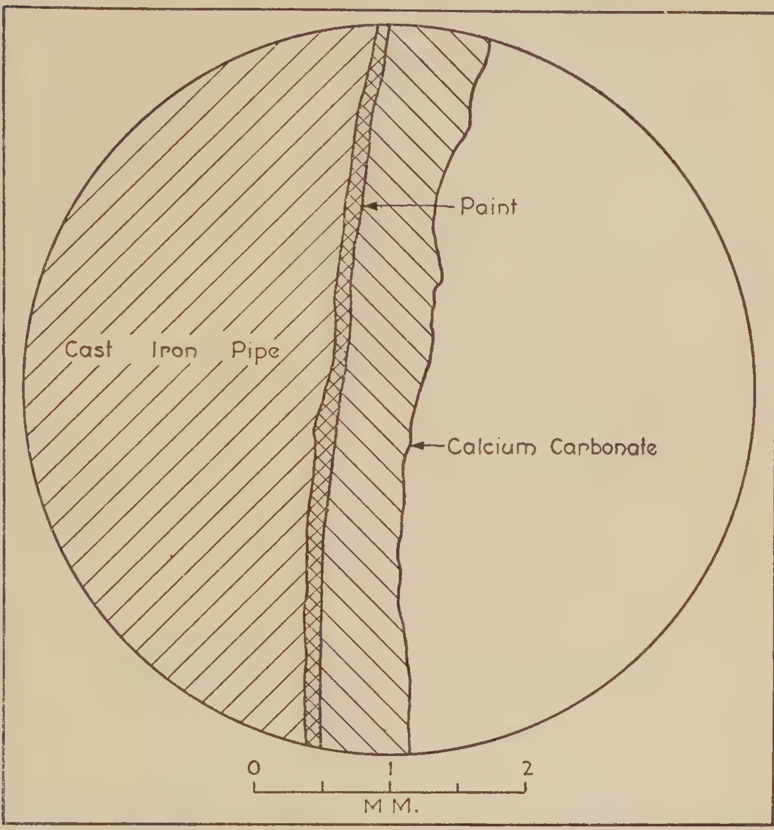


FIG. 11. CAMERA LUCIDA DRAWING OF CALCIUM CARBONATE PROTECTIVE COATING ON THE INSIDE OF PIPES AT NEW ORLEANS, LA.

Water after treatment at the filtration plant has a slight tendency to precipitate calcium carbonate. This offers almost complete protection to the pipes. The average thickness of the coating after about seventeen years of such treatment is about 0.6 mm.

only a matter of two or three years until they are again clogged. All indications point to the fact that cleaning cast iron mains of tubercles hastens their final destruction by corrosion.

The corrosion of cast iron does not dissolve all materials mixed

with the iron. Consequently when removing a tubercle there is no indication of where the pit is located unless the surface is scraped with a chisel or some other sharp tool. Even though practically all iron is dissolved from the pit the other constitutents of the cast iron hold together firmly enough not to be removed by any ordinary method now used in cleaning pipes. The pit being filled with a ferrous salt such as ferrous sulfate or ferrous chloride, conditions are ideal for immediately starting the formation of fairly large tubercles. This is not to advise against cleaning the tubercles from water pipes, for it may be necessary to get the desired amount of

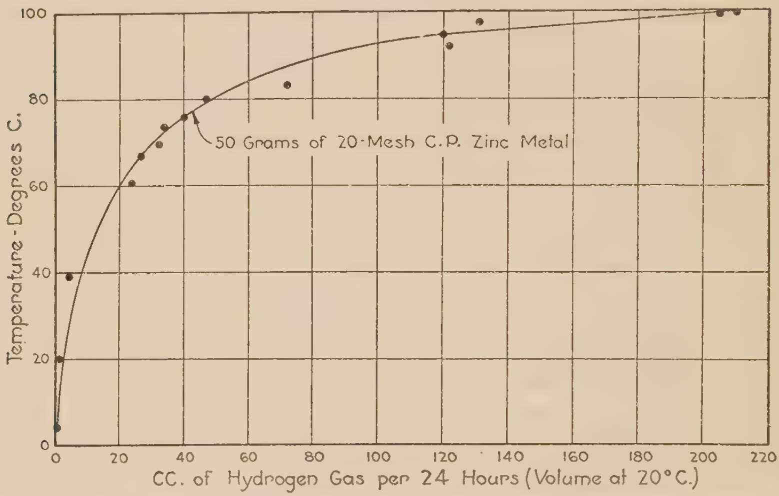


Fig. 12. The Effect of Temperature on the Initial Corrosion Rate of Zinc in the Absence of Oxygen

water through, but the relief is only temporary. If there were some treatment whereby an impervious coating could be quickly deposited on the pipe surface it might be of great aid in retarding corrosion and clogging. The writer knows of no treatment to recommend in such instances, but it is possible that sodium silicate may be used to advantage. Fairly large tubercles will form over pits before a coating of calcium carbonate can be deposited, for it takes several months to form a coating with water as alkaline as it is practical to use.

STUDIES ON THE EFFECT OF TEMPERATURE NOT COMPLETE

Experimental work on the effect of temperature on corrosion is under way, but has not progressed to the point where positive results

can be stated. A few hot water lines have been examined, and a few experiments made with temperatures between 20° and 100°C. The tests so far show nothing contrary to recent literature, in that an increase in temperature increases corrosion rates. Increasing the temperature probably aids in several ways. Diffusion rates are increased, thereby enabling soluble compounds aiding corrosion to be brought against the metal surface much more rapidly. The thickness of the oriented layer of water against solid surfaces appears to be much less for hot water than for cold. This enables the soluble salts within the film of rust to diffuse through more freely.

Increasing the temperature of 50 grams of 20-mesh laboratory zinc in distilled water and in Baltimore tap water from 20° to 55°C. increased the rate of liberating hydrogen gas about 2 times, and increasing to 100°C. the rate was increased to nearly 100 times the rate at 20°. This is shown in figure 12. In these tests the hydrogen gas was cooled to 20° before measuring. With the device used for collecting and measuring the hydrogen gas very accurate measurements can be made.

TABLE 10

The effect of temperature on the rate of hydrogen gas liberation by the corrosion of zinc

TEMPERATURE	HYDROGEN GAS MEASURED AT 20°C.
°C.	*cc*
20	1.3
37	2.2
53	3.6
95	120.0
100	175.0

Fifty grams of 20-mesh C.P. zinc metal were placed into a 300-cc. pyrex flask and Baltimore tap water added. The water had alkalinity 50, pH 8.5 and CO_2 0.0.

There also appears to be another factor aiding the corrosion of zinc by hot water. The surface film of zinc hydroxide is not built tough enough to protect the zinc metal as is the case when the temperature is lower. This, and the rapid corrosion rate of zinc in hot water, is probably why galvanizing on the inside of hot water lines does not last very long.

IT IS ECONOMY TO TREAT WATER TO PREVENT CORROSION

The City of Baltimore has about \$25,000,000 worth of cast iron mains, and about \$4,000,000 worth of laterals leading from the mains to the curb stop. In addition to this there are about 165,000 homes and business houses with water connections. The value of the iron pipes in these houses is probably \$8,000,000. The pH of the Baltimore water after coagulation with alum is between 6.0 and 6.8. This is about the same pH as the water which is being supplied a number of cities without any treatment to prevent corrosion. A fair estimate of the average useful life of cast iron pipes exposed to such an acid water is about seventy-five years, and for galvanized iron pipe not over twenty years. The twenty years estimated life of service pipes is the average of both cold and hot water lines. The hot water lines, of course, do not last as long as the cold water lines.

Treatment of the water to the point of coating the pipes with a thin film of calcium carbonate should more than double the useful life of pipes, if all corrosion were from the inside. It is safe to say that with such a treatment the life of cast iron pipe will be increased at least fifty years and the service pipes at least ten years, even after taking into consideration corrosion from the outside. \$25,000,000 worth of cast iron pipe at an estimated useful life of seventy-five years will have an annual depreciation of about \$333,000 and \$4,000,000 worth of household lateral owned by the city and about \$8,000,000 worth of iron pipes privately owned, with a life of twenty years will have an annual depreciation of about \$600,000. With the water treated to prevent corrosion, which will give a useful life of one hundred and twenty-five years for cast iron pipes and thirty years for the smaller pipes, the annual depreciation is about \$200,000 and \$400,000 respectively. This gives a grand total annual depreciation of \$933,000 for the acid water and \$600,000 for the properly treated water, or a saving of \$333,000.

The cost of treatment to reduce corrosion in Baltimore has averaged about 33 cents per million gallons for the past three years, or a total of about \$12,000 annually. The increase in hardness, which averages about 10 to 12 parts per million, probably adds from \$15,000 to \$20,000 annually for additional soap, etc. On the other hand there is a saving by preventing stains on bathroom fixtures and clothes being laundered, and, in addition, the value of

satisfied consumers. This should at least partially overbalance the added cost. If the Baltimore water were treated to the point of almost entirely preventing corrosion the cost would be about 20 per cent higher than the figures given. If we assume that no value should be placed on satisfied consumers, the total annual saving would still be nearly $300,000. With the present treatment where corrosion is not entirely stopped the saving is somewhat less, but at least $200,000.

These figures may not apply in the same proportion in other cities having corrosive water, but there will at least be a great saving. There is also the possibility that the life of iron pipes are not correctly estimated, but whatever be the life in slightly acid waters, it will be greatly extended by properly treating the water. When some of the other losses caused by corrosion which are numerated in the first paragraph of the article are taken into consideration the saving will be even greater than the figures above given.

THE WATER SUPPLY OF THE CHICAGO AND NORTH WESTERN RAILWAY[1]

By R. E. Coughlan[2]

On the Chicago and North Western Railway, the importance of suitable water for locomotive boiler use has been recognized for many years. This railroad is one of the pioneers in the soft water field.

Our road, comprising in all 10,215 miles of tracks, extends from Lake Michigan to the Rocky Mountains, traversing in all nine states.

Our problem has been to secure the best water available at all of our water stations and when this water is unsuitable for economical boiler operation, to render it so by means of chemical treatment, keeping in mind at all times the fact that the primary function of a boiler is to furnish power for the successful operation of machinery.

The water available for boiler use varies from the soft water of Northern Wisconsin, some of which contains as little as two grains of temporary hardness, to the very hard water of Minnesota and Dakota, some of which contains as high as eighty grains of temporary and permanent hardness per gallon. In certain parts of Wyoming and Dakota, the available water is known as "alkali." This water, while containing very little hardness, has in solution an excessive amount of the alkali sulphates and carbonates which have a tendency to cause boilers using it to prime. This is a serious menace to successful boiler operation. A special treatment is required when using this kind of water.

Throughout Northern Wisconsin and Michigan, the water is generally soft, so that very little treatment is required to keep the boilers in excellent condition. Such treatment as is used is applied directly to the locomotive tanks. This treatment consists of sodium carbonate commonly known as "soda ash."

The first definite step in the improvement of the quality of the water before supplying it to locomotive boilers on our road was made

[1] Presented before the Illinois Section meeting, March 25, 1926.

[2] Supervisor of Water Supply, Chicago and North Western Railway, Chicago, Ill.

early in 1903 on our main western division in Iowa, known as the "Iowa Division." This division extends from Council Bluffs to Clinton, Iowa, a distance of 348 miles, and over it is hauled a large percentage of grain and live stock on the way to Chicago and Eastern markets. Trains of this nature must be moved without delay as a loss of several hours in reaching the market may mean a direct financial loss to the carrier. Prior to 1903, it was the practice, when the traffic was heavy, to have reserve locomotives in readiness along the division to relieve locomotives liable to fail because of leaking or other boiler troubles.

The initial step in water improvement consisted of the construction of 16 lime and soda ash plants throughout this district. The entire installation was completed in 1904.

With these softening plants in operation, the locomotive boilers showed an improvement that was almost unbelievable. The resulting increased life of boilers, lower maintenance cost, fuel saving, etc., soon returned the initial cost of these plants. The reserve locomotives became a thing of the past and today our passenger locomotives operate over this entire district each day, being held in the terminals only long enough for the necessary running repairs. A boiler failure because of leaking is unknown.

These original plants were of the intermittent type and with the exception of the first one were all constructed by our own forces. As funds became available this program of construction was extended until there were 30 softening plants in operation at various water stations in Illinois, Iowa, Minnesota and Dakota.

After the World War, our interrupted program was again taken up. In 1922 we installed two of the modern plants of the continuous type.

In 1923–4, five, and in 1925, six were installed. The program of improvements for this year includes eleven more.

Our present daily consumption of softened water is approximately 4,000,000 gallons. From this volume of water, we remove over seven tons of scale forming solids per day. Some idea of the financial value of removing this amount of scale may be obtained if we refer to an investigation made by a committee of 10 engineers of the American Railway Engineering Association in 1913. They reported that the use of boiler water containing at least 13 grains of scale forming matter per gallon, caused a loss due to excessive fuel consumed, excess boiler

repairs and time out of service that amounted to 7 cents per pound of scale contained in the water.

In 1923 another committee of the same association, consisting of 27 engineers, made another investigation on this subject. The following quotation is taken from their report in Vol. 25, No. 261, November 1923.

> Your committee is of the opinion that the money value of the damage done to railroad revenue by the use of waters only moderately unsuitable has been much under-estimated, and that the custom common to all railroads of keeping a locomotive in a bad water district for three or four months, then transferring it for the balance of the year to a good water district, and distributing the repair charges has much befogged the issue.
>
> We have checked the measurements of your Water Committee of 1913, who reported in Vol. 15 of the Proceedings, that a boiler using water of 13 grains per gallon hardness, suffered damage in fuel and boiler repairs and time lost to the amount of 7 cents per pound of scale, and we consider them quite accurate on condition that the amount is raised to 13 cents per pound of scale to correspond to the prices of today.

In the operation of these water softening plants, we endeavor to reduce the original hardness to 3 to 5 grains per gallon. Zero hardness applied to some of the natural waters which we soften would result in a water which we call "light." This means that the water contains in solution so much sodium sulphate or similar substances that, when used in a boiler, it causes priming or foaming and the steam instead of being dry contains considerable moisture which is a detriment to economical boiler operation. We are obliged to use this class of water in parts of Wyoming and Dakota and in order to overcome this tendency, a special treatment known as anti-foaming boiler compound is used. The cost of this treatment is quite high and while we use it on all locomotive districts where necessary, we prefer to hold our treatment for scale to a point where the boilers are kept in good condition without causing any light water.

Our locomotive engineers are carefully coached and encouraged to reduce the concentration in the boiler while in operation by means of short openings of the blow off cocks at frequent intervals.

In addition to the complete lime and soda ash plants, we have 40 soda ash plants. These are small auxiliary pumps or similar devices which force dissolved soda ash into the storage tanks in direct proportion to the amount of water pumped. This is a satisfactory method of eliminating the permanent hardness of waters at stations

where we have, as yet, not installed complete lime and soda ash plants.

We have always used some boiler compound at points where we have no softening facilities. These compounds are made by our own forces under supervision of our chemical laboratory. During the past five years, we have been developing ways and means for securing the best results when this kind of treatment is used. We have devised several feeding arrangements and each terminal where this treatment is used is furnished with a test outfit. The foreman in charge makes daily tests of samples of water taken from the locomotive boilers. These test results are sent into the laboratory daily and are checked against analyses made at regular intervals. By this means, we are able to control the treatment, and have secured very satisfactory results.

In checking the records of boiler performance for the past 15 years, we find that in 1911, when our road was partially equipped with softeners or other treatment, we had 787 locomotive failures due to leaking flues. The average for the year was 58,633 miles per flue failure. In 1925, we had 27 locomotive failures from this cause, and the average was 1,770,119 miles per failure. During the year 1925, our Division in Iowa, equipped with softeners built in 1903, had an average of 7,125,421 miles per flue failure.

Each year we are striving to do better. Our management is keenly alive to the benefits derived from operation of locomotives which are furnished water free from impurities. We have the co-operation of not only the Motive Power Department, which is vitally interested, but also the Engineering Department, Traffic Department, and all our general officers, who realize the direct financial return, when boilers are supplied with suitable water.

That the general public is becoming interested in this subject is shown by an article in the Chicago Daily Tribune, March 23, 1926, entitled "Railroads Show Steady Increase in Efficiency" from which I quote the following:

> Some of the means by which railroads are getting more work out of their equipment are little known to the layman. For instance, did you know that the Iron Horse is becoming ever more a bottle nursed animal? Nowadays they have to treat his boiler water as carefully as a mother modifies her baby's milk.
>
> A change from raw, muddy water—as is—to soft and clean water, has been known to save $4,000 per year per locomotive in repairs and increased fuel efficiency. It isn't the water after all which is dangerous, it's what's in it.

DISCUSSION

K. Holaday: In regard to the control of your treatment plants how much supervision do they have by a chemist?

R. E. Coughlan: The operation of the softening plants is under the jurisdiction of the Engineering Department. The pumpers in charge make daily reports to the Engineer of Tests. Samples of treated water are sent in twice a week for analysis. The raw water is analyzed as often as required to keep in touch with the varying character of the water. Where the pumpers have test apparatus, daily tests are made and reported. The operation is checked as often as possible by a chemist. The water supply foreman is responsible for the satisfactory operation of the plant.

L. R. Howson: Does the control of the plants on the Illinois Central differ?

C. R. Knowles: Not materially. The operator makes daily tests. A chemist visits the plant once or twice a week or sometimes not for two weeks.

L. R. Howson: Who has the responsibility of changing treatment?

C. R. Knowles: The operator. At Galena, for example, there may be a shower in the hills and in thirty minutes the character of the water would be changed. It is necessary that the operator be responsible for change in treatment.

L. R. Howson: In some municipal plants treatment of water may be shown to be economical, if it will allow saving one half bar of soap a week for each domestic consumer. Another saving is in heating coils. From an investigation in one town the average cost of heating coils with untreated water was estimated at $12.00 a year.

C. R. Knowles: Our only trouble is to trim down the actual figures on the saving from use of treated water so that they will be readily believed and be acceptable.

Paul Hansen: How much salts are present before you classify water as light?

R. E. Coughlan: We have found it necessary to use anti-foam compound when the water in the boilers exceeds a concentration of 400 grains per gallon of alkaline salts. With anti-foam compound we can carry about four times this concentration. By means of the blow off cocks our enginemen reduce the concentration where the anti-foam compound is not used below 100 grains per gallon. Our treated water usually has an alkali content of less than 75 grains per gallon. We have a general working schedule that anti-foam compound will not be used unless our alkaline salt content shows over this amount. We also try to carry all of our treated water to 1 grain excess of sodium carbonate.

A. M. Buswell: Do you always use an excess of soda?

R. E. Coughlan: Yes, the alkalinity of the treated water is always slightly greater than the hardness.

Paul Hansen: What is the basis of your anti-foaming compound?

R. E. Coughlan: Castor oil.

A. E. Gorman: Is the basis of the successful use of castor oil physical?

R. E. Coughlan: We consider the reaction to be a physical one in that it reduces the surface tension.

M. M. Symons: How much oil is used?

R. E. Coughlan: We use a mixture containing approximately 15 per cent of castor oil. One pint of this mixture is sufficient to hold down 7500 gallons of water.

Question: Is the treated water used for domestic consumption?

R. E. Coughlan: If the raw water supply is safe the treatment will not to my knowledge render the water unfit for domestic use. Theo-

retically it is a very dilute solution of Glauber salts, which as you know is a standard remedy in veterinarian practice. At one point on our lines we turned the treated water into the city mains in an emergency due to the failure of the city supply. This was continued for a period of some weeks and when the city again turned the old water into the mains the consumers complained of the taste, as they had grown to like the taste of the treated water. No ill effects from the use of treated water have ever come to my attention on our road. We do not use it, however, on any of our coaches or in any place where it is liable to cause any comment whatsoever. We do not consider it at all injurious, but we do not want to cause any apprehension in regard to the water furnished the traveling public.

C. R. Knowles: I drink the treated water in preference and many of our employees do, but we do not furnish it to the public on our trains.

THE COLI-AEROGENES GROUP IN SOIL

By Stewart A. Koser[1]

Since the introduction of simple methods for separating the coli-aerogenes group of bacteria into several sections, the so-called fecal and non-fecal types, there has been considerable discussion regarding the practical application of these methods in the sanitary examination of water. Some workers claim that they are useful in arriving at a correct judgment of the sanitary quality of water, while others state that they are of no value.

It is clear that to evaluate these tests accurately we should have as extensive knowledge as possible regarding the types of colon group organisms found both in the feces of man and animals and in various soils, for it is evident that most of the coli-aerogenes types which make their way into water supplies are derived ultimately from one or another of these sources. It now appears clearly established that the Bacterium coli section comprises about 95 per cent of the colon-like organisms found in the intestines of man and the higher animals, while in contrast to this Bacterium aerogenes and its allies predominate in soil. However, the latter are by no means the only colon-group representatives to be found in soil, for organisms resembling the intestinal coli type have also been encountered, though usually in smaller numbers (1).

In this connection it should be recognized that from the sanitary point of view different soils may vary widely, since some are obviously exposed to fecal contamination to a greater degree than others. It seemed desirable to determine whether the proportion of the various coli-aerogenes types in soil would vary in harmony with the degree of fecal contamination to which different localities may be exposed. Such a comparison would serve to throw some light upon the value of the differential tests as criteria of pollution, not only as applied to soils, but indirectly as applied to surface water supplies, since the coli-aerogenes population of springs, wells and streams may be derived largely from soil.

[1] Department of Bacteriology, University of Illinois, Urbana, Ill.

In the present investigation 52 soil samples were taken at different points over an area about 15 by 20 miles in the central eastern section of Illinois. This section is practically all farm land and is largely under cultivation. The samples were collected during the months of June and July. The general type of soil in this locality is a brown silt loam. The hydrogen-ion concentration does not vary over a wide range from either side of neutrality so that extremely acid or alkaline soils were not encountered.

From a sanitary standpoint the soils should be divided into two groups based on the apparent degree of fecal pollution to which they had been exposed. The first group consisted of samples from ordinary fields under cultivation (corn, oats, wheat, rye, alfalfa, clover), while the second was represented by soil from pastures. The soils constituting the first group were exposed to only chance fecal contamination such as might come from animals employed in cultivating the fields or from dust blown across from neighboring country roads. Very little information was available as to previous fertilizer treatment of the fields, though none of them had been recently manured. The samples which are considered in the second group were taken from pasture lands in which animals were grazing and the soils here represent a rather high degree of pollution. In each case the pastures had evidently been used for this purpose for some time.

In the examination of soil for members of the coli-aerogenes group several methods are available. Portions of the sample may be enriched in lactose broth, or plates may be made directly from suspensions of the soil in sterile distilled water. Each method has certain obvious disadvantages: in the process of lactose enrichment certain types may be overgrown and lost so that a true picture of the relative distribution of the several types is not obtained, while by direct plating many colon group organisms may be missed, especially if they are not particularly abundant. In the present work both methods were used.

Samples of surface soil were collected in sterile wide mouth bottles and transported to the laboratory within a few hours after collection. The following procedure of examination and cultivation was adopted: from each sample approximately 10 grams of soil were transferred with aseptic precautions to a small flask containing 100 cc. of lactose broth, then 1.0 gram and 0.1 gram quantities were inoculated into ordinary lactose broth fermentation tubes. Smaller amounts were examined by direct plating. Suspensions in sterile water were

made and amounts approximating as nearly as possible 0.01 and 0.001 gram of soil were plated directly in Endo medium. Endo or eosin-methylene blue plates were streaked from the lactose enrichment cultures and colon-like colonies transferred to agar slants and to lactose broth for reisolation. Only one culture was picked from each plate unless entirely different types of colon-like colonies were present, in which case one of each was isolated. Such a procedure seemed necessary in order to avoid getting from the plates a number of cultures all of which might have resulted from the multiplication of one

TABLE 1

Summary of results on soil samples examined for coli-aerogenes group

	TOTAL NUMBER SOIL SAMPLES EXAMINED	SAMPLES NEGATIVE	SAMPLES YIELDING COLON GROUP CULTURES	TOTAL NUMBER CULTURES OBTAINED
Cultivated fields	41	7	34	104
Pastures	11	0	11	33

TABLE 2

Occurrence of coli-aerogenes group as shown by isolations from varying quantities of soil

	10 grams.	1 gram.	0.1 gram	0.01 gram.	0.001 gram.
Cultivated fields (104 cultures)	24	43	25	3	9
Pastures (33 cultures)	10	8	8	0	7*

* All 7 cultures were isolated from one sample.

original cell in a lactose broth enrichment tube. Any colon-like colonies appearing upon the plates which were poured directly from the diluted suspensions of soil were isolated for further study. On many of these plates no colon-like colonies were encountered, though a great many soil forms developed and in some cases the plates were too crowded for use.

It will be seen that, by the foregoing method of examination, different quantities ranging from 10 grams to approximately 0.001 gram of each soil sample were cultured. The results should give some idea of the relative abundance of the coli-aerogenes types on the soils

under investigation. It is realized, of course, that by any available method of cultivation some organisms may be overgrown or otherwise lost and that the results obtained can be regarded as only an approximation of the actual conditions.

A summary of coli-aerogenes isolations from both cultivated fields and pastures is shown in table 1, while some idea of the relative abundance of these types is given in table 2. It is evident that by far the greater number of isolations was obtained from the 10, 1 and 0.1 gram quantities and relatively few cultures were obtained from the smaller amounts. A few exceptions to this were encountered with individual samples, for occasionally cultures were obtained only from the smaller quantities of a particular sample. It seems probable that in these cases the colon group organisms were overgrown by other forms and could not be detected in the larger amounts of soil. This same effect is seen also in a comparison between the number of isolations from the 10 and 1-gram samples from cultivated fields. Here, although an equal number of samples was examined in each case, only 24 cultures were obtained from the 10-gram amounts, whereas 43 were secured from the 1 gram quantities.

Another point relative to the occurrence of the colon group in soil was noted. This was the apparent irregularity in distribution of the organisms in different samples of soil, even when collected from the same general locality. Not infrequently, upon examination of several samples of soil collected from different parts of the same field, cultures would be obtained from the 10, 1 and 0.1 gram quantities of one sample, while from another no cultures at all could be isolated. Evidently the distribution of these forms is far from uniform, even in the same general locality and type of soil. In this connection it should be noted that 7 of the 41 samples from fields yielded entirely negative results, while from a few samples cultures were obtained from a one to one thousand dilution.

All cultures were replated, in some instances a number of times, to insure purity before determining their behavior toward the differential tests. The methyl red, Voges-Proskauer and citrate tests were used and on the basis of these the cultures could be assigned to one or another of the sections shown in table 3. Here we have first the well-known aerogenes-cloacae section, next the Bacterium coli section consisting of cultures which on the basis of the differential tests are similar to fecal Bacterium coli and lastly, the so-called intermediate section comprised of those cultures giving a positive methyl

red test but which differ from the true intestinal coli on the basis of the citrate test (2). In cultivated fields, with only the possibility of chance intestinal contamination, the aerogenes-cloacae types predominated and included slightly over 67 per cent of the colon group cultures obtained from this source. The Bacterium coli type comprised about 23 per cent of the cultures while the intermediate type was found in relatively small numbers. Two atypical cultures were also found. The pastures represent an entirely different condition. Here there was abundant contamination with fecal material and this is reflected in the great increase in the Bacterium coli type which was more abundant than even the aerogenes section. The intermediate type was found less frequently than before. Apparently the normal soil forms have been "snowed under" by the large increase in numbers of the intestinal organisms.

TABLE 3

Showing the proportions of the different coli-aerogenes types found in soils

	CULTIVATED FIELDS (ONLY CHANCE FECAL POLLUTION)		PASTURES (HIGHLY POLLUTED)	
	Number	Per cent	Number	Per cent
Aerogenes-cloacae section (MR−, VP+, citrate +)	70	(67.3)	11	(33.3)
Bact. coli type (MR+, VP−, citrate−)	24	(23.1)	21	(63.6)
Intermediate section (MR+, VP−, citrate +)	8	(7.7)	1	(3.0)
Atypical:				
MR−, VP−, citrate +	1	(0.9)		
MR+, VP+, citrate +	1	(0.9)		
Totals	104		33	

The significance of these results may be brought out further by comparison with a previous investigation (3) in which the same differential tests were applied to a series of coli-aerogenes cultures isolated from the soils of hill tops and mountain tops, where there seemed to be little if any chance of pollution. From a sanitary standpoint the soil of these localities would be ranked ahead of any included in the present study. In such situations the aerogenes section predominated as would be expected, the Bacterium coli type comprised only 2.8 per cent of the cultures, while the intermediates ec-

tion included 31.9 per cent of the cultures. Taken in connection with the present investigation it is clear that the differential tests bring out a correlation between the type of colon group organisms and the degree of fecal contamination.

SUMMARY

From the foregoing results several points are brought out:

1. Members of the coli-aerogenes group were found to be fairly abundant in the soils of cultivated fields and pastures.

2. Their distribution appears to be irregular, some samples yielding negative results, while from other samples cultures were obtained from relatively small amounts of soil.

3. The results of the methyl red, Voges-Proskauer and citrate tests brought out a general correlation between the proportion of the various sections of the colon group and the apparent degree of fecal pollution of the soil. The proportion of the Bacterium coli type (Mr+, VP−, citrate−) increased with the amount of fecal contamination and was highest in the soil from pastures.

REFERENCES

(1) For a summary see Levine, M.: Bull. 62, Eng. Exp. Station Ames, Iowa, 1921. Also Prescott and Winslow: Elements of Water Bacteriology, 1924.

(2) Koser, S. A.: Jour. Amer. Water Wks. Assoc., 1924, vol. 12, p. 200.

(3) Koser, S. A.: Jour. Bact., 1924, vol. 9, p. 59.

AUTOMATIC PRIMERS FOR CENTRIFUGAL PUMPS[1]

By F. H. Bradford[2]

The APCO automatic primer for centrifugal pumps consists of a tank divided by partition in the middle into two parts, one above the other, arranged for connections to the pump. The lower half is connected to the suction and the upper half to the discharge side of the pump.

The purpose of the APCO primer is to automatically prime a valveless pump without the use of a foot valve or any other mechanical contrivance which might be subject to wear and tear or service disabilities. By the use of the automatic primer a horizontal pump may be used on suction lifts to the limit of its ability to raise water by suction.

Automatic primers are usually made of tank iron, but may be made of other materials as the necessities of the occasion may demand. The operation is as follows:

When first installed the lower chamber is filled with water and as the level of the water is above the top of the pump casing, the pump is primed and ready to start. When the pump lowers the liquid in the lower chamber, the air within the top thereof and the suction pipe expands to fill the space and in so doing drops in pressure. Before the suction pipe is uncovered the atmospheric pressure will force the liquid from the vessel to be emptied through the suction pipe into the top of the lower chamber and falling through the body of air therein is drawn out by the pump, which discharges it into the upper tank. When the pump is stopped the air valve at the top of the upper chamber opens and allows the liquid to return by gravity through the pump to the lower chamber, forcing the air back through the suction line, thus flushing the suction line and repriming the system.

Automatic primers are especially useful for automatic or remote control and can be used to advantage where the service requires frequent starting and stopping, such as on automatic sump work.

[1] Presented before the Illinois Section meeting, March 24, 1926.

[2] President, Automatic Primer Company, Chicago, Ill.

They are being used in isolated sewage plants, private water systems, on drainage projects and in fact nearly every conceivable kind of service where there is a suction lift and prompt and dependable priming is a factor of importance.

The use of the automatic primer may be limited by the size of the tank and the space available for installation. On very long suction lines, especially where there is a high suction lift, the size of the primer might necessarily have to be too large for the size of the pump with which it is to be installed, but as centrifugal pumps are located close to the source of supply, the limitations cited are not necessarily of great importance.

Primers are practically fool-proof and if properly installed can not fail to work in accordance with claims made for them for the principle of operation is based on physical laws, and not on mechanical means for accomplishing the desired result. Each size of primer is adapted to a maximum condition or service and naturally the duty to be performed must be within the limit of capacity.

A short time ago we had occasion to prepare new literature and thought it advisable to answer in this literature the questions that are asked most frequently. In examining our files and making a search for questions we were surprised to find that all were practically the same. Answers to them are as follows:

There is no possibility of air binding the pump.

There is no possibility of air binding the primer, as the water which enters from the suction line falls through the air which is trapped in the lower chamber and entrains more than sufficient air to compensate for any air or vapor which might be released from the water when it is placed under vacuum.

The vacuum break connection is made for the purpose of breaking the vacuum on the back flow when the pump is shut down. When the flow of water is reversed, there is a siphoning action which has to be broken or an air pocket might form in the pump which would interfere with the starting operation. The vacuum break introduces air at the top of the suction chamber just as soon as the opening in the discharge line is uncovered on the back flow. Introduction of air at this point allows the water in the suction line to fall and the original equilibrium to be restored. When the pump is operating there is a slight leakage of water back through the vacuum break into the suction chamber, but owing to relative pipe sizes this leakage is usually less than 1 per cent.

Air pockets in the discharge line are unlikely, as any air passed by the pump would accumulate in the top of the upper chamber and escape through the air valve. This air valve is positive and will not pass liquid. The following advantages are claimed for this equipment:

It does away with foot valves.

It has no moving parts with the exception of the float in the air valve.

It is dependable for automatic and remote control.

It does not require manual operation.

It eliminates mechanical equipment subject to wear and tear and service disabilities.

It avoids danger of freezing as the suction line is filled with air when the pump is shut down.

It makes horizontal centrifugal pumps superior to other types for suction possibilities.

It has a low first cost.

COPPER IN THE DISTRIBUTION SYSTEM FOLLOWING WATERSHED TREATMENT[1]

By F. E. Hale[2] and Henry F. Muer[3]

During recent years it has been the practice of the water department of New York City to resort to continuous automatic treatment with copper sulphate of the Catskill water as it passes from Ashokan to Kensico reservoir to prevent seeding the storage reservoir near the City with organisms prevailing in the upper watershed reservoir. The extent of this practice is shown as follows:

1920	3 months	(5 periods)
1921	1 month	(2 periods)
1922	5 months	(4 periods)
1923	6 months	(3 periods)
1924	5 months	(3 periods)

Synura has been present each fall in Ashokan reservoir in small quantity and to avoid any repetition of the experience with synura in the winter of 1921, treatment of the water in the aqueduct has been continuous all winter until about the middle of February. After this date untreated water could not reach the effluent chamber of Kensico reservoir in several weeks or until ice would be off Kensico so that direct treatment of that reservoir could be made if necessary.

Synura appeared as usual last fall in Ashokan reservoir and automatic treatment in the aqueduct with copper sulphate at the rate of one pound per million gallons, 0.12 p.p.m., was started on October 11, 1924 and continued until January 29, 1925. A separate growth of synura prevailed at the same time in Kensico reservoir so that it became necessary to treat the lower portion with the same dosage, which was carried out on October 23, 24, 25 and 27 from the dam to Bear Gutter point or about half way to the influent chamber. The

[1] Presented before the Water Purification Division, Louisville Convention, April 29, 1925.

[2] Director of Laboratories, Department of Water Supply, Gas and Electricity, New York, N. Y.

[3] Chemist in charge, Mt. Prospect Laboratory, Brooklyn, N. Y.

distance between the influent and effluent chambers is about three miles. The depth ranges from ten feet at the influent chamber to one hundred feet at the lower end. The treated portion ranged from fifty to one hundred feet in depth and dosage was apportioned to volume. The water leaving Kensico reservoir passes through Hillview reservoir of 900 m.g. capacity or about one and one-half day's storage at present rate of draft.

Several times during previous experience search had been made for copper in the distribution system of the City, evaporating one and one-half gallons of water for test, and not a trace had been found. This winter it was decided to make a more extended search. Of the regular daily samples collected at Shaft 23, Brooklyn, 200 cc. portions were taken and combined until 4 liters were obtained, representing about three weeks. This composite was analyzed for copper. The procedure began October 19, 1924 and has been continued to date.

On November 24, 1924, a series of samples was taken from the surface water of Kensico reservoir to ascertain the extent of residual synura following the treatment of the previous month. Three samples taken in the upper area from Bear Gutter point to the influent chamber were combined and tested for copper and likewise four samples taken between Bear Gutter point and the dam were combined and tested.

Table 1 shows the results of these examinations.

The astonishing feature is that copper was continuously present until four weeks after the automatic treatment stopped, a period probably roughly equal to the time of flow from influent to effluent chamber. The amounts would indicate either an uneven admixture of the copper with the water or a certain striation of the precipitated copper. The dosage both of the reservoir and in the automatic treatment was 0.12 p.p.m. based on total volume. It seems probable that the copper combines with the organic matter of the microscopic organisms as well as with the alkalinity and may either float or sink or be continuously affected by the winter circulation of the water which takes place from top to bottom all winter. Apparently all the copper fed into the supply came through into the distribution system. The first composite from Shaft 23 probably represents the reservoir treatment but all the others the aqueduct treatment. It will be interesting to note in future whether the same thing occurs in other periods than winter, since real stagnation occurs in summer.

The amounts of copper found were too small to be of sanitary significance. Whether they are of industrial importance, such as in

photography or in dye manufacture, is a question for future decision, considering the experience of Baltimore with small amounts of manganese in the laundry industry.

The method employed in determining these minute amounts of copper was as follows:

The composite samples ranged from 2.3 to 4.2 liters and the weight of copper determined from 0.1 mgm. to 0.5 mgm. As a routine procedure 4 liters was adopted. As the ratio of copper to crystalline copper sulphate is as 1:4, the

TABLE 1

Determination of copper in water supply

DATE	LOCATION	VOLUME OF WATER	WEIGHT ELECT. Cu	TITRATION Cu	†Cu	‡$CuSO_4 \cdot 5H_2O$
		liters	*mgm.*	*mgm.*	*p.p.m.*	*p.p.m.*
November 24, 1924....	Kensico reservoir, upper area	2.28	0.5		0.22	0.88
November 24, 1924....	Kensico reservoir, lower area	3.16	0.4*	0.10	0.03	0.12
October 19, 1924–November 5, 1924	Shaft 23, Brooklyn	4.25	0.5	0.42	0.11	0.44
November 16, 1924,–December 5, 1924...	Shaft 23, Brooklyn	4	0.2	0.18	0.05	0.19
December 7, 1924–December 26, 1924.....	Shaft 23, Brooklyn	4	0.3	0.22	0.07	0.26
December 28, 1924–January 16, 1925....	Shaft 23, Brooklyn	4	0.1	0.14	0.03	0.12
January 18, 1925–February 6, 1925........	Shaft 23, Brooklyn	4	0.3	0.30	0.08	0.30
February 8, 1925–February 27, 1925........	Shaft 23, Brooklyn	4	0.3	0.20	0.06	0.25
March 1, 1925–March 20, 1925.............	Shaft 23, Brooklyn	4	0.0	0.05	0.01	0.04
Average..................................			0.24	0.22	0.06	0.23

* Deposit dark and ammonia blue color slight.

† Average of weight and titration, with exception of reservoir results.

‡ Calculated to form in which it is applied.

amount of copper determined as Cu equals parts per million direct of copper sulphate as applied.

The composite, acidified with 5 cc. of 1:1 nitric acid, is evaporated to dryness on a water bath in a platinum dish. The residue is gently ignited by fanning with a gas flame until the small amount of organic matter remaining is burned off. The evaporation with nitric acid destroys most of the organic matter and oxidizes any iron to ferric condition.

The residue is now transferred to a 3-inch porcelain evaporating dish by treating with 5 cc. of hot 1:1 nitric acid and thoroughly scrubbing with a policeman, repeating the scrubbing with a second 5 cc. of acid and washing with two portions of hot water.

The contents in the porcelain dish is again taken to dryness to get rid of excess nitric acid and thoroughly dehydrate silica. The residue is moistened with 1 cc. of 1:1 nitric acid, diluted with 15 cc. of hot water, filtered on a small filter and washed with successive small portions of hot water from the top down. The filtrate and washings are caught in a 60 cc. non-sol beaker, volume about 30 cc. This process gets rid of the large bulk of insoluble solids from the gallon of water taken.

The filtrate is now treated with 1:1 ammonia in distinct excess to precipitate iron and hold copper in solution, boiled, settled, filtered on a small filter paper, and washed with hot water made slightly alkaline with ammonia. The filtrate is transferred to a 3-inch porcelain evaporating dish again, concentrated to about 10 cc. to precipitate the last traces of iron, filtered through a small filter, washed with successive portions of hot water from the top down. The filtrate and washings amount to 20 cc. and are caught in a 60 cc. non-sol beaker.

Then 5 cc. of 1:1 nitric acid and 5 cc. of saturated solution of potassium sulphate are added. The latter assists copper to deposit completely in a bright clean manner. Electrolysis takes place over night (sixteen hours) using 110 volt D. C. lighting current through a 10 watt lamp, i.e., 0.10 ampere. The electrodes used are platinum spirals (of #16 B. & S. gauge wire) weighing about 13 grams each. About 1 inch is immersed in the liquid. Copper may be readily seen down to 0.1 mgm. There should be no odor of ammonia in the liquid after electrolysis due to reduction of the nitric acid; if so the deposit will be black and oxidized. The coils are washed with distilled water with the current on while lowering the beaker until free from the liquid. This is a necessary precaution as it does not take nitric acid long to dissolve traces of copper with the current off. The coils are dipped in alcohol, heated over a gas flame until the alcohol has evaporated without igniting, cooled in a desiccator and weighed.

As a check the deposit is dissolved by rolling the cathode in 3 cc. of 1:1 nitric acid in a test tube and washing in 3 cc. of distilled water in another tube. The washing is added to the acid solution and nitrous oxides boiled off, then made alkaline with 1:1 ammonia. Even traces of copper in small volume give a blue color and an estimate of amount may be made by comparing with known amounts of copper solution similarly treated.

As a further check the ammoniacal solution is acidified with acetic acid in the test tube, treated with a crystal of potassium iodide, the size of a pea, and the resulting iodine set free titrated with N/100 thiosulphate, using a 2 cc. pipette graduated to 0.02 cc., and starch solution as indicator. Each cubic centimeter N/100 thiosulphate equals 0.635 mgm. Cu.

These two checks are of advantage in denoting the purity of the copper deposit. The agreement between the electrolytic weight and the titration is shown in the table and is reasonably close.

FLOW OF WATER IN PIPES[1]

By Hiram F. Mills

A REVIEW BY ALLEN HAZEN[2]

This book of 236 beautifully printed quarto pages presents the results of more than fifty years study of hydraulic problems by a man of unusual capacity for observation and analysis.

The material relates mainly to the flow of water in pipes, and was intended to be the first part of a complete treatise on hydraulics, but these pages represent all of the work that the author's strength and life permitted.

The studies were made in the first place to find means for accurately measuring the water supplied by the Essex Company of Lawrence, Mass., to the various mills on its canals for power. The work was afterwards greatly extended by Mr. Mills, we may believe, for the pure love of finding the exact truth. We know that for a period of many years the project of a treatise on hydraulics lay dormant while even more important matters occupied his attention.

The statement of experimental methods used in 1875, beginning on page 147, leaves one in doubt which to admire most, the sturdy, simple measures taken to find out the exact truth, or the clear, concise English in which the methods are pictured. These pages bring to the writer the memory of what he saw at Lawrence during the years when he helped Mr. Mills with other matters. He remembers the numerous observing stations manned by careful, conscientious young men, observing water levels at predetermined intervals, and writing down the results to be plotted and averaged and compared, until everything was checked and accounted for beyond a possible doubt. The writer knows something of the thorough methods of Mr. Mills for they were also applied to the work which he did at Lawrence. Each of the experimental results stated in the tables

[1] With historical and personal note by John R. Freeman and introductory outline by Karl R. Kennison. Privately printed.

[2] Consulting Engineer, New York, N. Y.

is the average of many single tests, and one feels that the results can be depended upon for such strict accuracy as is rarely found in the records of experimental work.

The amount of new experimental material on the flow of water in pipes is very large, and its character is of a high order. It includes the records of flow in small brass pipes made by Mr. Mills himself, and in larger brass pipes by his former assistant, Mr. John R. Freeman, extending to pipes as large as 4 inches in diameter, and to velocities as high as 30 feet per second. The text gives some idea of the care taken to prevent roughness at the joints and on the interior surfaces, and the coefficients that were obtained, not exceeded by any since obtained, are convincing evidence of the thoroughness with which all roughness and obstruction were avoided.

Other experiments by Freeman on wrought iron pipes from the smallest commercial sizes up to 8 inches in diameter, and with velocities extending to 13, and in some case to over 20 feet per second are recorded. Other experiments on wrought iron pipe by J. B. Francis, cover a much shorter range of velocities, and there are experiments on cast iron pipe, new and old by Mr. Mills, and by several of his assistants and associates.

The experiments upon one line of specially prepared 12-inch cast iron pipe made during the years from 1875 to 1882, are unique in their thoroughness. No less than 1045 separate determinations are summarized in the tables of results.

To the rich data made available to Mr. Mills, he added the results of published experiments which he believed to have been reliable, and the whole mass of data was then analyzed to determine as far as possible the laws of flow. Many matters are taken up and the business developed to form a complete treatise on the flow of water in pipes.

All the elements of flow are discussed, including size, material, age and condition, but, from the present standpoint, perhaps the matter of greatest scientific interest to us is the study of the relations between velocity and slope or friction. The experiments available covered a remarkable range from low to high velocities with the greatest accuracy. The method of study was unique and would be only possible with the very best of data. It is carried out in a way that, as far as the writer knows, has never been elsewhere attempted.

Below the critical velocity, the friction increases as the first power of the velocity. This old law Mr. Mills found to almost exactly

represent the facts. At higher velocities the friction increases nearly as the second power of the velocity, but it is not exactly the second power. It is usually some fractional power materially less than the second power. These small and varying deviations from the second power could not be accepted by Mr. Mills without adequate explanation.

There was much of the mystic in his makeup, and with Swedenborg, he regarded water as the material emblem of Truth. No effort was too great to find out exactly what took place and why.

His description of the flows near the critical velocity as determined by piezometer measurements and otherwise, is one of the most interesting things to be found in this remarkable volume. His study shows that passing upward, as the critical velocity is passed, there is not an abrupt change in the method of flow, but that, instead, there is a gradual introduction of a rolling of the water and a new element of resistance growing out of it not existing at lower velocities, and this new element increases exactly as the square of the velocity, but does not make up the whole of the resistance, for some of the conditions of flow below the critical velocity still continue at higher velocities and are only gradually displaced. Even at full ordinary velocities an appreciable amount of the conditions of the low flows remains, especially with pipes that are quite smooth.

An ingenious mathematical analysis of the record of each pipe separates these elements and shows the amount of each. Charts show graphically how and when the changes come about. There is finally presented a table on page 165 which shows, among other things, how the elements operating at lower velocities and depending upon temperature and viscosity persist in some measure in smooth pipes and in smaller measure in rough pipes at higher velocities. From all this it is easy to see that what we have long known and have expressed roughly by fractional exponents, is really based upon deep-seated laws of flow.

In studying the flows near and for some distance above the critical velocity, Mr. Mills has developed two intermediate formulas to cover the transition stage, and, with these, for a given pipe, there are in all four formulas of flow, one for the range below the critical velocity, two for intermediate or transition stages, and the last for higher velocities. It is not to be supposed that these formulas will displace the ordinary short-cut approximate methods in common use, but it is certainly interesting to see how apparently erratic

variations near the critical velocity can be explained and are found to be parts of one harmonious system.

The writer remembers that in 1892, as he was making some hydraulic calculations for Mr. Mills, he was given a paper showing how those calculations were to be made. This remained among some old prized papers until long afterward. In 1919, he came across it and was struck anew with the merit of the idea which it represented. He called Mr. Mills' attention to the matter at the time and suggested publication and received from Mr. Mills a kindly letter in which it was explained that Mr. Mills hoped to publish the whole work some time and that in the meantime he wished to have the matter held confidential. Needless to say the wish of Mr. Mills was respected, but notwithstanding this, it would be difficult to say to what extent the ideas of the writer and perhaps of others have been influenced by Mr. Mills' work, and to what extent his ideas have found expression and extended use, even though the publication was so long delayed.

Our most cordial thanks are due to Mr. Freeman and to Mr. Kennison for making this material available to us, and it is to be hoped that the announced intention of presenting an abstract to the American Society of Civil Engineers of which Mr. Mills was an honorary member will be carried out.

WATER CERTIFICATES TO FINANCE WATER SUPPLY PLANTS IN ILLINOIS[1]

By Paul E. Green[2]

It frequently occurs that a municipality, although vitally in need of enlargement of its source of water supply, is unable to finance a new plant. The bonding power of Illinois municipalities is limited to 5 per cent of the assessed valuation. Assessing authorities, for political reasons, usually strive to maintain this valuation as low as possible, with the idea that they are keeping down taxes. This of course is only very narrowly true, but the net result is that the municipality has very low bonding power for needed new construction. Taxes are just about as high as they would be in any case, since the rate must be high, and all revenue which can be raised is used for current expenses. A study of tax rates and valuations is very illuminating.

The Illinois law provides for the issuance, under certain circumstances, of water certificates for the purchase, construction, or enlargement of a water plant. There are several acts under which this may be done, but the one most commonly used is that entitled "An Act authorizing cities, towns and villages to build, purchase or extend water supply systems for public and domestic uses and to provide for the cost thereof." Approved April 22, 1899, and in force July 1, 1899. In payment for such building, purchasing or enlargement the municipality may issue certificates of indebtedness, limited in their payment solely to the water fund provided for in the Act. These certificates of indebtedness bear interest at a rate not exceeding 6 per cent and shall be issued for not less than par.

The Act further provides for a schedule of rates, a referendum if 20 per cent of the voters so petition within three weeks of passage of the ordinance, and that the proceeds arising from the operation of the system shall be paid into a water fund, out of which the certificates of indebtedness, or as they are usually termed the water certificates, shall be paid. This water fund must not be used for any

[1] Presented before the Illinois Section meeting, March 24, 1926.

[2] Consulting Engineer, Chicago, Ill.

purpose except to retire these certificates or to pay the necessary operating expenses of the system, and the rates may not be reduced during the life of the bonds.

It is further provided that a mortgage deed of Trust of the water works system may be executed and acknowledged and recorded in the same manner as a mortgage on private property.

In case there is default in payment of the principal or interest, the trustee is authorized to take over the operation of the plant and, if necessary, to raise the rates, and finally to sell the plant in order to satisfy the provisions of the trust deed. Furthermore, if it becomes necessary to sell the plant the municipality is not permitted to construct or operate, or authorize any other person or corporation to construct a system of water works.

It is evident that the intention of the framers of this Act was to provide a means of financing the construction of a water works plant as a public utility, able to stand on its own feet and show an actual profit of sufficient amount to pay for itself. A number of cities and villages in Illinois have taken advantage of the procedure, among which may be mentioned Marion, Carbondale, Herrin, Lemont, Lockport, Brookfield, Glenview, Carterville, Quincy, and probably several others.

The Act has some concealed dynamite in it, and in some cases some rather unusual legal difficulties have been encountered. No part of the system paid for by other means can be included in the mortgage. Some attorneys, whose opinion as to the legality of municipal issues in Illinois is essential if the issue is to be disposed of to advantage, have taken the position that in spite of the fact that the municipality is not, under the Act, obligated as a whole, the issue must be considered as coming under the constitutional limitation of 5 per cent. While they do not condemn the method, they fear it is unconstitutional and will not render an opinion. Since the cost of the works contemplated under the water certificate plan may be more than the constitutional limit, it is obvious that this is a pretty serious obstacle. It should be emphasized that these water certificates or bonds are payable out of the proceeds of the operation of the plant itself and that the only security is the plant. Because of the position taken by such attorneys, even if the municipality had previously voted a general bond for any purpose and such bonds have not been sold prior to the sale of the water certificates, it becomes difficult to secure an acceptable legal opinion on the prior bonds. While other

eminent legal authorities will approve of the water certificates, their opinion is not acceptable on general bonds and the corporation is thus between the devil and the deep sea. Hence, any municipality intending to use the water certificate act would do well to issue and sell its general bonds first.

These water bonds have not been considered first class paper, and have been disposed of at prices varying from 75 to 95. Because of this fact, and also because engineers have not always been consulted in the matter, the practice has grown up of making it a contractor's job rather than a city or engineer's job. The author is of the opinion that such a result is vicious and unnecessary. The law requires that the certificates or bonds shall be issued at par. This provision has been seized upon as making it necessary that the contractor must take the bonds, sell them secretly at a discount, (which is no one's business) and bid accordingly. He handles the entire issue and pays the fees of the engineer and attorney. Such a method means that the usual procedure is reversed, and instead of the city holding the purse strings the contractor holds them and dictates, in a large degree, to the engineer who supervises the work.

The same arguments which are used here would hold for special assessment bonds, but in practice have been found to be erroneous. There is no question but that properly drawn plans and carefully worded specifications can as completely keep the control of the water improvement in the hands of the proper city officials, as are other improvements. Because of this abnormal situation contractors have actively promoted water supply jobs, submitted very general and inadequate plans and specifications prepared by engineers on a contingent basis, and at times have secured the work. Some of it has been undoubtedly badly done and exorbitantly charged for.

The idea back of this method of financing water obligations is sound and provides a means of securing an adequate water supply for cities and villages which would have difficulty in securing it otherwise. It would seem as if a test cast brought to the Supreme Court on its merits, in which the issue is clean cut, would clear the situation amazingly. The decision should either demolish the act or so clear the air that the securities would be placed in an unassailable position. Undoubtedly this will occur in time, but by that time the present rather vicious mode of handling these bonds may have become so settled that it will be difficult to alter the procedure. It is believed,

therefore, that any municipality which takes advantage of this Act should proceed as follows:

1. It should employ competent engineers and attorneys to handle the work without reference to any contractors, and not on a contingent basis. This would result in

(*a*) A minimum of expense, since it is not necessary that complete detailed plans be prepared before the necessary legislation is passed by the municipal body.

(*b*) Very decided decreased legal costs, since the procedure is simple, not nearly as complicated as the Local Improvement Act, and requires no more legal work than is required in a general bond issue. The preliminary legal and engineering fees should not exceed about one per cent. Under the prevailing method the engineering fees have been less, but the legal fees much greater, as our legal brethren are accustomed to contingent fees.

2. It should finance, if possible, some separate part of the improvement by means of a general bond issue, and issue and sell the general bonds first. Thus the land and the reservoir may be purchased from the proceeds of the water certificates, while the pumping plant, located elsewhere, may be constructed from the proceeds of the general bond issue. If this procedure is followed, genuine competitive bids may be obtained on properly prepared plans. The working details can be drafted after proper legislation is so advanced that the contingent fee is eliminated. The matter of discount need cause no worry, since it will either disappear entirely as the procedure becomes more settled, and previous issues of such securities have been paid off, or it may be legally and properly taken care of by carefully drawn clauses in the specifications and bidding sheet.

If it be assumed that the legal procedure has been properly observed, the most important part of the legislation providing for improvements under this Act is that which schedules the rates to be charged for water, the provision for retirement of the certificates or bonds themselves, and the allocation of the earnings between the new and old plants. There is no limit set in the law as to the amount of the issue, but it is obvious that one based on inadequate earning capacity and which provides for very long term bonds will be difficult to sell, and even if sold will bring a low price. Bond brokers are not over scrupulous as to the amount of the issue, provided any sort of showing can be made as to the operating profits. The more bonds

that are issued, the greater is the commission. The price paid will be based on the revenue, and, if in their opinion, the revenue is overestimated and the life of the bonds too long, it will be reflected very decidedly in the price offered for the issue.

The engineer who is preparing a rate schedule must analyze the earning capacity of his water plant very completely. He must so adjust his rates as to encourage the use of water but not its waste, and furthermore must so arrange his brackets or divisions that the maximum amount of revenue will be obtained from the operation of the plant. This can only be obtained by a detailed study and analysis of the past individual meter readings and revenues. Here enters also the question of allocation of the earned revenue between the original or general bond issue plant and the new one; for this method of financing practically presupposes an existing plant with an established business. If such analysis is carefully and competently made and the fixed annual cost so adjusted that the burden is minimized during the first few years of operation, the issue can be made a decidedly attractive one. If the total issue is so calculated that the revenues, after deducting operating costs, exceed by approximately 50 per cent the bond requirements, the issue can be sold at a figure not far below par, and when practice is stabilized there can be but little question that this class of securities will approach and pass par.

The effect on a municipality of successfully financing an improvement under this Act is to improve the efficiency of its water plant. It is subject to the scrutiny of the Trustee, and must produce sufficient revenue to retire the bonds. Under this law the revenue cannot be diverted and all water must be metered, and no free water can be furnished to anyone. The net result is an efficiently and economically conducted public utility.

RAPID FINE SAND FILTRATION[1]

Frederick E. Field:[2] Mr. Blaisdell has given us a paper which should be of interest to those who are engaged in the design, construction or operation of filtration works.

With regard to the desirability of placing the filter sand, when in a wet condition, in the bed and the removing of all entrained air, we have often noted that filter specifications require the placing of filter sand in thin layers and the settling of each layer by flooding by an upward flow of water, at a low rate, and also that before a drained filter is placed in service, it is common practice to backfill at a slow rate to remove the entrained air.

Mr. Blaisdell, however, has gone a step in advance and shown by actual experiments the need of particular care in these respects, if filters of fine sand are to operate satisfactorily at high rates.

REVERSE FLOW TESTS

As the writer coöperated with Mr. Blaisdell in the "high rate" and "reverse flow" tests at the Montreal Filtration Works, he finds Mr. Blaisdell's statements in regard to these of much interest, since it is the first time reference to these tests and experiments have been noted in publications.

Mr. Blaisdell's description of the tests with the 18-inch experimental filters at Montreal is so complete as to make further comments of little value.

He did not include however with his paper any of the charts therein mentioned, and possibly some of these will make these experiments of more general interest.

We therefore include charts for the 18-inch Experimental Filters Nos. 1 and 2 for the months of September and October, 1921.

These show the average daily rate of filtration and the gradual increase of the loss of head as the filters became clogged. They also show the reduction in loss of head by means of the "reverse flow."

[1] See Journal, December, 1925, page 581.

[2] Filtration Engineer, Water Board, Montreal, Quebec, Can.

In addition, the October charts show the daily turbidity of both the "raw" and the "filtered" water and the percentage of turbidity reduction.

During September both experimental filters were supplied with water of low turbidity, but during parts of October the turbidity of

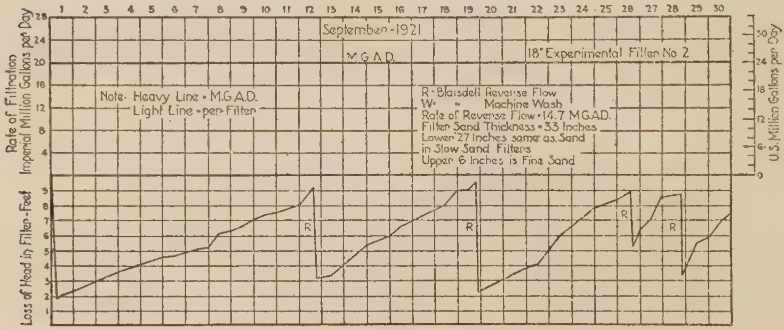


FIG. 1. BLAISDELL REVERSE FLOW FILTRATION TESTS

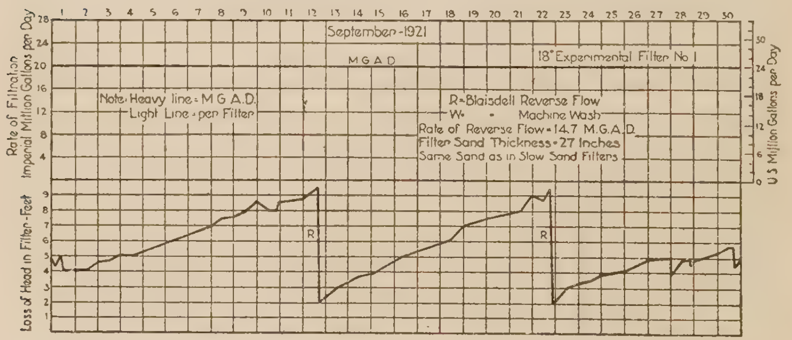


FIG. 2. BLAISDELL REVERSE FLOW FILTRATION TESTS

the St. Lawrence River water was artificially increased to as high as 120 p.p.m. The decreased lengths of runs and the results of the "reverse flow" under the change of conditions are clearly indicated on the charts.

REVERSE FLOW TESTS ON FULL SIZE FILTERS

The results of the tests with the 18-inch experimental filters made it desirable to conduct similar tests on the final slow sand filters of the Montreal Plant.

The Montreal Plant is designed for, and normally operated by, a system known as "Double Filtration," which means that the effluent from the rapid sand pre-filters passes through the final slow sand filters before entering the filtered water basin.

These final filters are 340 feet long and 57 feet wide (center to

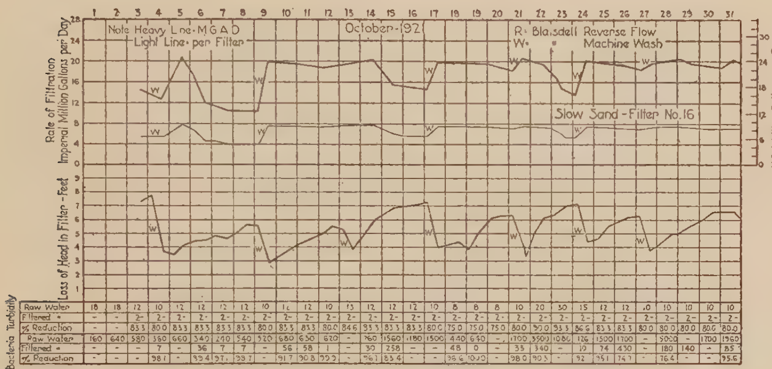


FIG. 3. BLAISDELL REVERSE FLOW FILTRATION TESTS

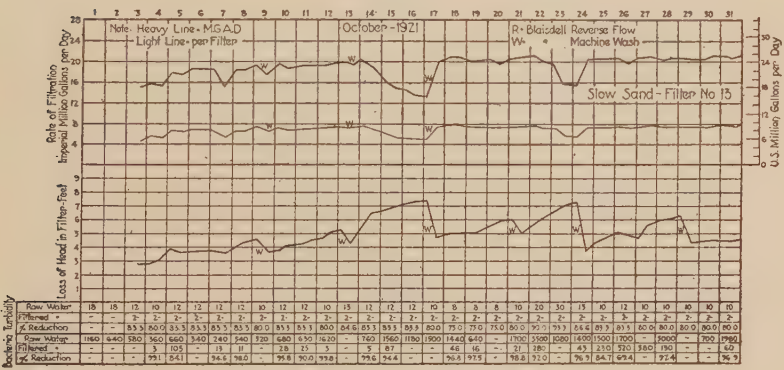


FIG. 4. BLAISDELL REVERSE FLOW FILTRATION TESTS

center of dividing walls) and are each divided by columns, supporting the roof, into 3 longitudinal bays.

Each final filter, with a sand area of $\frac{3}{8}$ acre, has for filter material, 12 inches of graded gravel and 27 inches of filter sand having an effective size of 0.25 to 0.35 mm.

The underdrainage system consists of two half-round 8-inch tile

laterals in each transverse bay which discharge into a central main collector 30 inches in diameter and extending the entire length of the filter below the floor level.

The filter washing is done by Blaisdell Washing Machines which run on longitudinal tracks in each bay. These machines rake and

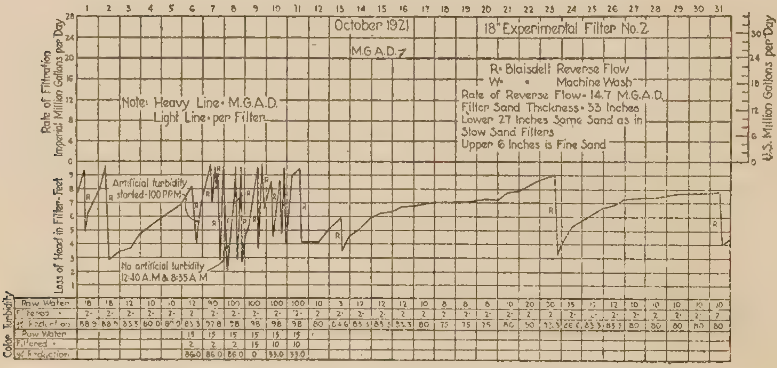


FIG. 5. BLAISDELL REVERSE FLOW FILTRATION TESTS

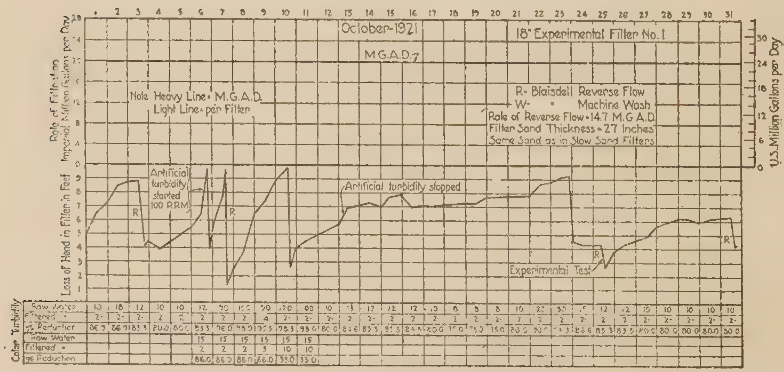


FIG. 6. BLAISDELL REVERSE FLOW FILTRATION TESTS

wash the sand to any desired depth, leave the sand clean and uniform and pump away to the drain all dirt and foreign matter which has accumulated since the last washing.

The normal rate for which the filter was designed is $8\frac{1}{4}$ m.g. (Imperial) or 10 m.g. (U. S.) per acre per day.

This description of the final filter will indicate under what conditions the "reverse flow" tests were conducted.

Four of the sixteen final filters were used in these tests, and we include four of the record charts, (i.e., those for October, 1921), to illustrate the results of the experiments.

Filter No. 2, was operated at the normal rate of 10 m.g. (U. S.) per acre per day for a comparison with filters Nos. 13, 15 and 16,

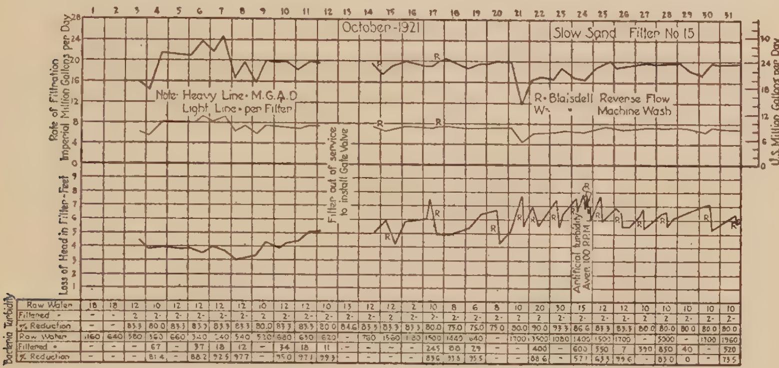


FIG. 7. BLAISDELL REVERSE FLOW FILTRATION TESTS

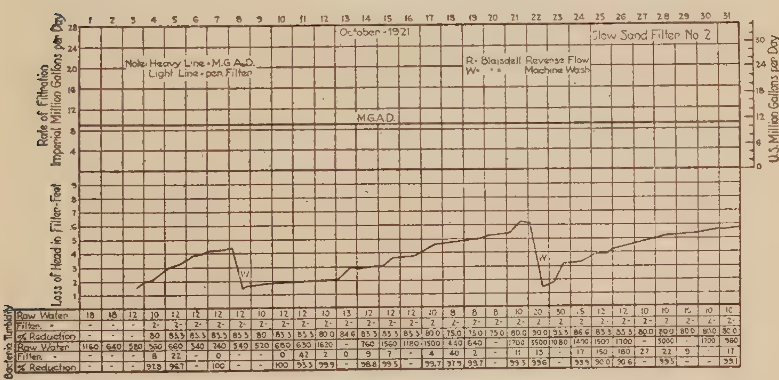


FIG. 8. BLAISDELL REVERSE FLOW FILTRATION TESTT

which during these tests were run at the average rate of 24 m.g. (U. S.) per acre per day.

Filter No. 15 was especially equipped for the "reverse flow" tests while filters Nos. 2, 13 and 16 were washed when required by the Blaisdell washing machines. Each of these charts show for each day of the month, the rate of filtration, the loss of head, the time and

results of "Machine Wash" or "Reverse Flow." Each chart also gives the daily record of turbidity of "raw" and "filtered" waters and the "bacteria count" in both raw and filtered waters with percentages of reduction in each case.

Two other charts are included, both indicating graphically, the comparison between the results obtained by the regular "Machine Wash" and by the "Reverse Flow."

All of these charts are self-explanatory and require little comment.

All "reverse" flows were at the approximate rate of 15 m.g.a.d. (U. S.) or a vertical rise of about $\frac{3}{8}$ inch per minute, as per instructions by Mr. Blaisdell. The rise was, by such tests as could be made, almost uniform all over the filter, notwithstanding the wide spacing of the lateral collectors.

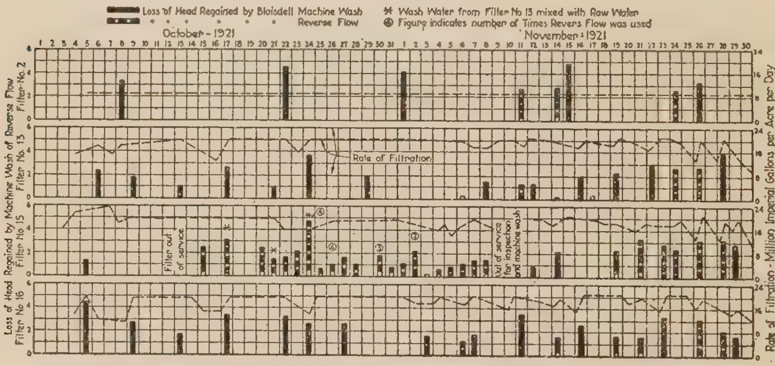


Fig. 9. Blaisdell Reverse Flow Tests, Machine Wash and Reverse Flow

For our final filters, this rate of 15 m.g.a.d. (U. S.) for the "Reverse Flow" required about 4000 gallons (U. S.) per minute, which was obtained from a pump purchased and installed for these tests.

On figure 9 you will note, that filters, Nos. 13–15 and 16 were operated at approximately the same rate, i.e. 20 m.g.a.d. (imperial), but that for a period of about one month or from October 5 to November 8, "Reverse Flows" on filter No. 15 took the place of seven (7) "Machine Washes" on filter No. 13 and eight (8) "Machine Washes" on filter No. 16.

In studying and analyzing the data on all these charts it should not be forgotten that these tests represent only preliminary experiments, undertaken only a few months after Mr. Blaisdell had first

conceived of the idea that his so called "Reverse Flow" might be of value.

In pioneer work of this kind where there are no precedents for guidance, progress is necessarily slow and mistakes often made.

About five months time was spent on these experiments at the

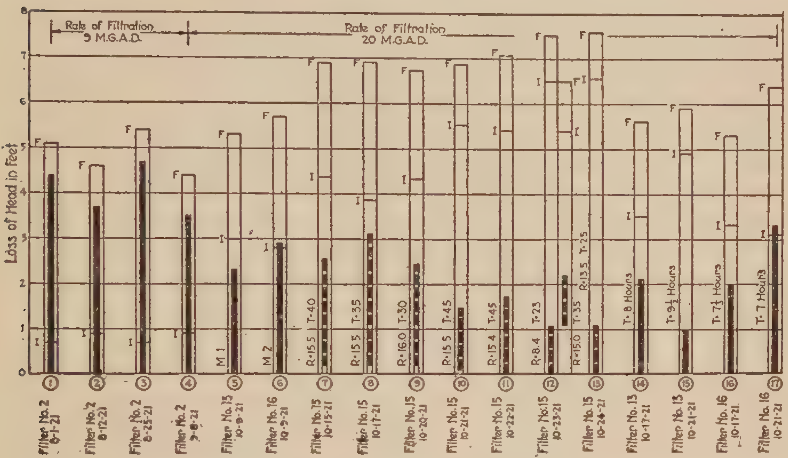


FIG. 10. BLAISDELL REVERSE FLOW TESTS, MACHINE WASH VS. REVERSE FLOW

F = Final Loss of head in filter before Blaisdell machine wash or reverse flow.

I = initial loss of head in filter after Blaisdell machine wash or reverse flow.

Solid black column = loss of head regained by Blaisdell machine wash.

Alternate black and white column = loss of head regained by Blaisdell reverse flow.

R = rate of reverse flow in million imperial gallons per acre per day (m.g.a.d.)

T = time of reverse flow in minutes.

M.1 = washing machine no. 1.

M.2 = washing machine no. 2.

Column 12 = combined reverse flow (i.e., second reverse flow immediately following first reverse flow). Note increase in loss of head regained by second reverse flow.

Note: Filter 15 had last machine wash on October 5, 1921. Since this date filters 13 and 16 have each had four machine washes. Moreover the dirty wash water from filter 13 has been applied to incoming water to filter 15 three times (i.e., October 9, October 17 and October 21) since October 5, 1921.

Montreal Plant, and the cost was considerable, as the filters, piping and water supply needs were not entirely suitable, which made it necessary to purchase and install much equipment.

We also found that filter No. 15 was somewhat abused by the "reverse flow" tests, as conducted, and required much extra work by the Blaisdell washing machines to again obtain the same condition of the sand bed as existed prior to these experiments.

During and subsequent to the experiments supervised by Mr. Blaisdell, Messrs. Kilpatrick and Harrington of the filtration staff did some similar work for their own information, and some of their observations may be of interest.

The initial loss of head in filters operated at low rates is much less than when the filters are operated at high rates of filtration, which may account for the greater loss of head regained by the "reverse flow" on filters having low rates. The varying elevation of the water in the main effluent conduit is also a factor which may explain to some extent the wide range in the results.

Averaging the results of the reverse flow tests on filters having the same rates of flow, we obtained the following:

Loss of head regained by reverse flow

TEST DATA	RATE OF FILTRATION, M. G. A. D. (IMPERIAL)		
	1⅓	9	20
Number of tests	35	3	18
Average final loss of head, feet	7.77	5.84	6.83
Average initial loss of head, feet	3.76	3.16	5.43
Average head regained, feet	4.01	2.68	1.40
Maximum head regained feet	6.38	2.22	3.28
Minimum head regained, feet	1.22	2.55	0.05

Mr. Blaisdell advises a "reverse flow" at the rate of 15 m.g.a.d. or about $\frac{3}{8}$ inch rise per minute. Some tests at Montreal with a vertical rise of $\frac{1}{8}$ inch per minute produced results not greatly different from those with higher rates of reverse flow.

The "reverse flow" has not been used at the Montreal Filters since the completion of the Blaisdell experiments for two reasons:

1. The gallery piping and water supply available are unsuitable for the reverse flow.

2. There has been no necessity for the use of the reverse flow.

Under normal operating conditions when the "double filtration" system is in use, the final filters require cleaning only about once each month. As two Blaisdell washing machines are available for this work, the filters are easily maintained in a condition for effective

service. In case of emergency, with one of the washing machines out of service, the "reverse flow" could be used to maintain full capacity of the filters under peak loads.

CONCLUSIONS

1. The tests made and the data thus obtained are not sufficient to establish how the "reverse flow" can be used most effectively, but indicate its possible value under certain conditions. Further experimental work may result in its more general application.

2. The "reverse flow" should not be used carelessly or when there are no means available to repair any damage to the sand bed occasioned by its improper use.

At the Montreal Filters any detrimental disturbance of the sand bed can easily be repaired and the filter restored to a satisfactory condition by one or more passages of the Blaisdell washing machines.

3. From the results obtained from "reverse flows" with a very small vertical rise per minute in the filter it would appear that the principal functions of the "reverse flow" are to remove any entrained air, and reduce, to some extent, the compacting of the sand due to the previous operation of the filter.

4. The quantity of wash water required for the final filters at Montreal is less than 0.1 per cent of the water filtered, and this wash water is the raw water above the sand at the time of wash and not filtered water.

Therefore no appreciable savings would result in this respect by the general use of the reverse flow.

Mr. Blaisdell mentions that the results of operation at the Eastman Kodak Company's filter plant are "satisfactory." It would be of interest to have details of the results at this plant, which operates at a rate of 16 m.g.a.d. and also to know if the "reverse flow" is a feature of the operation.

The writer is hopeful that Mr. Blaisdell's paper together with the additional information concerning the "reverse flow" tests at Montreal, now presented, will open the door to an instructive discussion of the subject which will be of mutual benefit.

Seth M. Van Loan:[3] Mr. Blaisdell's paper offers three subjects anyone of which is of vital interest to the operation of filter units approaching an acre in size and in which the sand depth, size and grad-

[3] Deputy Chief, Bureau of Water, Philadelphia, Pa.

ing has been designed and placed according to the general standard practice.

First: The author's reference to fine sand and its value in reduction ability deals more or less in a specific way with waters of a medium turbidity with a possible peak of 300 p.p.m. There is a broad difference in operating on the 6 m.g.a.d. basis and at 25 to 50 m.g.a.d. rate. Further reference might be made to the range the author announces as the possibilities of the use of fine sand. It would be of interest to have additional data relative to the operation at a 50 m.g.a.d. rate in which may be shown the turbidity and bacteria content of both applied water and effluent.

The applied and effluent waters to the Philadelphia filters, selecting the last calendar year (1925) for results, have averaged 7 and 0 respectively in turbidities, and 8300 and 4 respectively in bacteria. Recent tests of sand indicate the loss of finer particles, the analyses registering from 0.30 to 0.46 mm. in effective size and 1.98 and 2.16 in uniformity coefficient. Specificatons at the period of construction required an effective size of 0.32 m.m. and a uniformity coefficient of 1.65 with the under drain and outlet piping designed for a 6 m.g.a.d. rate. The rates at the various filter plants on a yearly average will register 2.8 to 3.4 m.g.a.d. The period of operating activity of these filters with the washing of sand necessary for service has reduced the amount of fine content in the first deposited sand. The practice in Philadelphia has been to build on the surface of fresh sand by operating upon a graduated rate, filtering from 0.5 m.g.a.d. rate to the maximum of 6 m.g.a.d. With the author's plan the units would, after cleaning, be immediately started and continued at a high rate, being limited only to the size of piping.

Second: Referring to "reverse flow" there may have been an unintentional approach to this at one of the Philadelphia plants during a winter season when the thickness of ice forced the operation of the filters into unusual measures. The beds were dead due to service and close to 8 inches of ice had formed on the water surface. The beds were drained below sand permitting the ice to rest on the sand. Backfilling was applied and the ice lifted after which the units gave a length of run to permit the removal of a certain amount of ice. There might be a question whether this approached the reverse flow theory or whether the general clogging influences were not adhering to the under surface of the ice and freedom was given for the cleaner sand to function. With a properly designed pipe and under-

drain system, there should be a softening effect of a back wash carrying the finer sand for a new imposed removal layer. To obtain a uniform wash over a bed approaching an acre in size would require careful design and equally careful construction.

Third: The filter washer. Two units of the Blaisdell crane type washer have been in use for years in Philadelphia. The latter installation continues to function on beds of the scrubbing type and its service has been satisfactory. At time of writing the Blaisdell Company is under contract to furnish several filter washing machines embodying the principles described by the author. The design provides a gasolene driven caterpillar tread machine which travels over the submerged sand and experimental work during periods of study have indicated that higher rates may be maintained, reduction of "out of service" periods and economy on sand cleaning effected.

John R. Baylis:[4] The article by Mr. Blaisdell on "Rapid Fine Sand Filtration" describes a very interesting method of increasing the rate of filtration for what is commonly known as slow sand filters; that is, filtration when the water is not coagulated by the addition of chemicals. A rate of filtration several times that of customary practice for slow sand filters is used. The literature on filtration contains no accurate measurement of the turbidity of the filtered water, neither does Mr. Blaisdell give the exact turbidity of the filter effluent for rapid fine sand filters. Consequently true comparisons cannot be made. It may be found when accurate measurments are made that there is a slight difference and that such high rates as suggested cannot be maintained. It seems probable, however, that rates considerably in excess of the now customary slow sand rates can be maintained with equal results. The method of making a clogged filter porous by reversing the flow of water at a rate so low that the suspended matter which has been filtered out will not be stirred up may mark an advance in slow sand filtration.

The article brings prominently to our attention the lack of knowledge on how a filter bed filters. Is filtration merely the straining out of the suspended matter, or is it the lodgement of the particles by being wedged in the interstices between the sand grains? Do attractive forces play any part in filtration? It is likely that all three methods by which suspended matter may be removed are brought into play in many filter plants. As to which will be the

[4] Principal Sanitary Chemist, Montebello Filters, Baltimore, Md.

prevailing one depends upon conditions. A brief explanation may be desirable. Straining is when the suspended particles are too large to pass through the pores of the filtering medium. After a short period of service the actual filtering medium may be largely the suspended matter which has been filtered out. Removal by lodge-

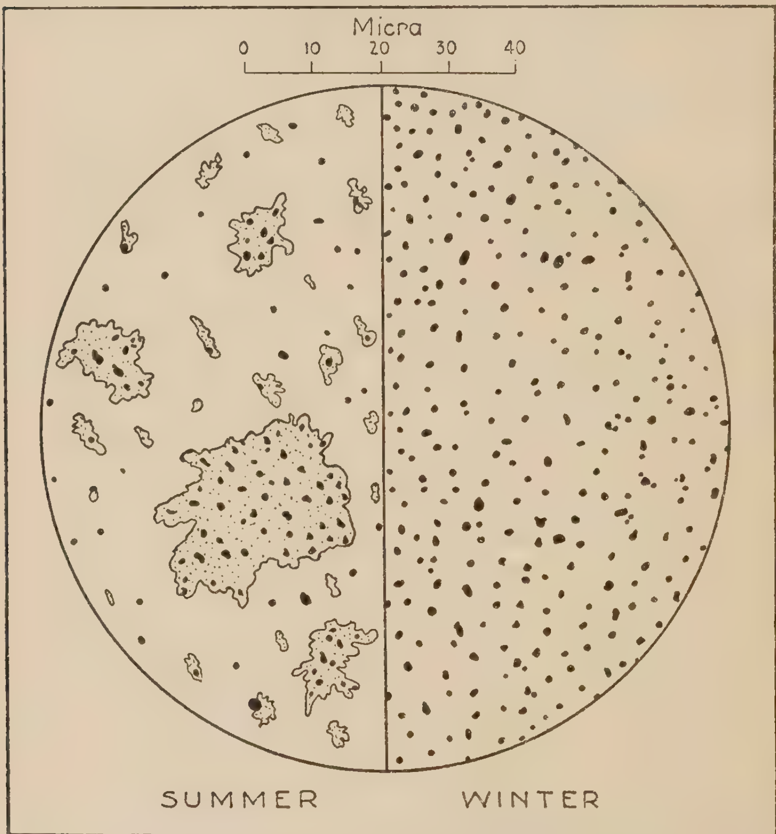


Fig. 11. Extreme Characteristics of the Turbidity of the Raw Water at Baltimore

ment probably can be best illustrated by assuming the filter bed greatly magnified. If the grains of sand were from 2 to 5 feet in diameter and the bed 400 to 500 feet deep, then the suspended particles would have to be from $\frac{1}{8}$ to over 1 inch in diameter to be on the same scale. If particles the size and shape of the enlarged

suspended particles were dropped on top of this pile of enlarged sand grains it is evident that very few would pass through. They would be wedged in the spaces where the sand grains touched. Attractive forces operate where there is a tendency for solids to be drawn together somewhat like the attraction of iron particles by a magnet. While not the prevailing factor in the removal of suspended matter, it is evident that part is removed in this manner.

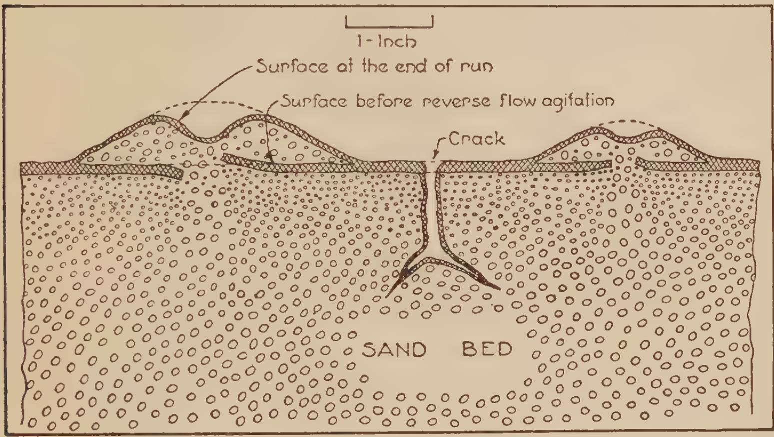


FIG. 12. CRACKS AND MOUNDS PRODUCED BY REVERSE FLOW AGITATION

When the filtration is nearly all in the surface of a filter bed a tough surface is soon formed, which causes the loss of head to rise rapidly. In such instances the beds may be agitated by reversing the flow to break the surface layer. The 24-inch wash water valves at the Montebello Filters, Baltimore Water Department, are opened 8 to 9 inches, let run for about one-fourth minute, and then closed. This breaks numerous holes through the surface and throws up small mounds of sand from 1 to about 10 inches in diameter. Slight cracks are also formed in other places, which soon open to larger cracks after the filters are in service a short while. Such a procedure frequently lengthens the filter run between washings nearly 100 per cent. Note the coarser sand grains thrown to the surface in the mounds.

Character of suspended matter quite variable. There is considerable difference in the character of the suspended matter in various waters. Figure 11 shows extreme conditions in the Baltimore raw water. The coarser particles shown on the left half of the camera lucida drawing are somewhat typical of size of particles at times. These particles are really nothing more than a partially coagulated water.

Such conditions usually occur in the warmer months, and is at least partially due to the production of organic jellies by biological growths. Most of the finer particles have been entrapped in the jelly or gelatinous precipitate. The right hand side of the drawing represents extreme dispersion of the suspended particles which sometimes occurs in the winter months. The water is between these extremes most of the time. The suspended matter in some water supplies may approach that shown on the left all the time, whereas others may approach that on the right a great deal of the time. Somewhere between these extremes is the point of fineness beyond which it is not safe to go, if good results are to be obtained by slow sand filtration. At such plants it is customary to use a coagulant

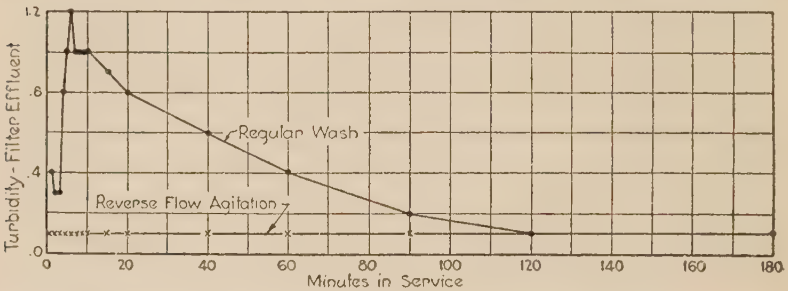


FIG. 13. COMPARISON OF THE TURBIDITY OF THE FILTER EFFLUENT AFTER A REGULAR WASH AND AFTER A REVERSE FLOW AGITATION. FILTER NO. 29

when the fineness exceeds the point where a clear filter effluent cannot be obtained. It may be possible that with the use of finer sand the limit of fineness beyond which the customary slow sand filter will not handle may be greatly extended.

What Mr. Blaisdell has done apparently has been to decrease the size of the pores through the sand bed and increase the rate of filtration. The result is an effluent approximately as satisfactory as that now being produced by slow sand filters. Increasing the rate of filtration and decreasing the size of the pores of the filter bed, of course, materially increase the rate at which the loss of head rises. To overcome this he reverses the flow of water through the bed at a rate just enough to open fine channels through the clogged layer. No water is actually lost in this treatment of the beds.

Reverse flow agitation occasionally used at Baltimore. Mr. Arm-

strong has used a procedure somewhat similar on rapid sand filter beds at the Montebello Filters during the warmer months when the

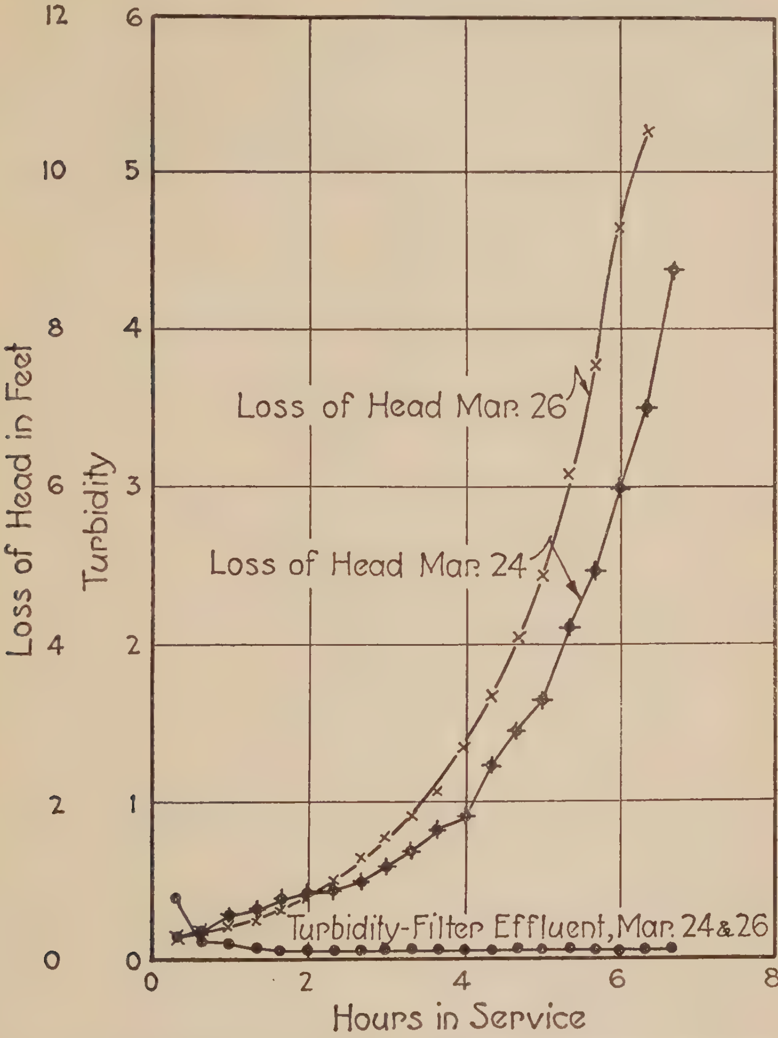


FIG. 14. LOSS OF HEAD AND TURBIDITY OF FILTER EFFLUENT WHEN THE FILTRATION IS LARGELY IN THE SURFACE LAYER

loss of head increased rapidly. In this case there is an actual disturbance of the sand bed as shown in figure 12. The surface layer

is not only broken, but small mounds of sand are thrown up. If properly done, a fresh surface nearly equal to the area of the original bed is formed by the mounds and the cracks which soon open up.

It has been customary to use the reverse flow agitation only once between washings at Baltimore, though it is possible that it may be used several times with satisfactory results. Comparison of the turbidity of the water after a regular wash and after a reverse flow agitation is shown in figure 13. For this particular test there was no increase in the turbidity after the reverse flow agitation. Mr.

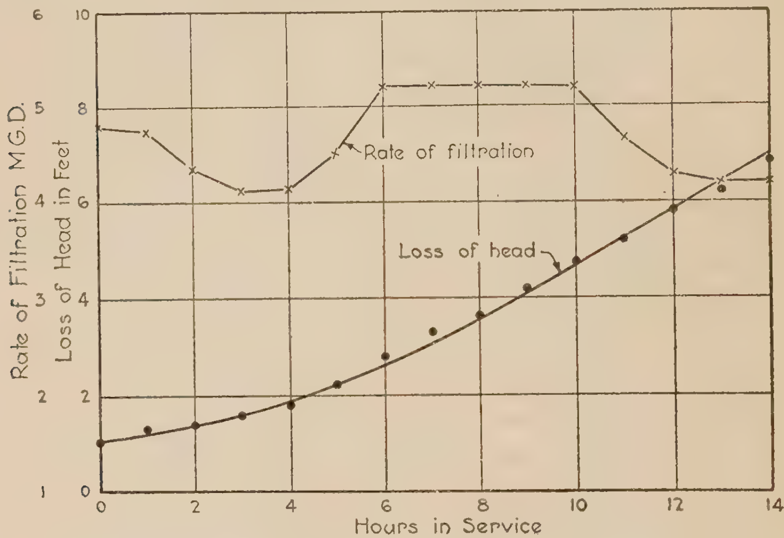


Fig. 15. Loss of Head and Rate of Filtration. Filter No. 10

Curves taken from circular recording chart. Note the increase in the rate of rise for the loss of head.

Hopkins of our laboratory has made a number of such turbidity measurements and there is no case where the turbidity has exceeded that of a regular wash. There are many instances, however, where there is some increase. It is our opinion that the filter runs are about doubled by such a procedure. This procedure, with varying degrees of agitation, is followed in many rapid sand filter plants at times when the filter runs are very short. Our experience indicates it to be good practice at certain seasons of the year, but it probably would not be for the major portion of the time. *It is good practice only when most of the filtration is in the surface layer.* Rapid fine sand filtration

apparently is the use of sand fine enough so that most of the filtration is in the surface, even though the suspended particles have not been coagulated by the addition of chemicals. As the surface layer becomes clogged pores are opened through it to sand deeper in the bed. The present procedure for slow sand filters is to scrape or rake the surface. The reverse flow may be applied with profit to some of the existing slow sand filter plants by increasing the time

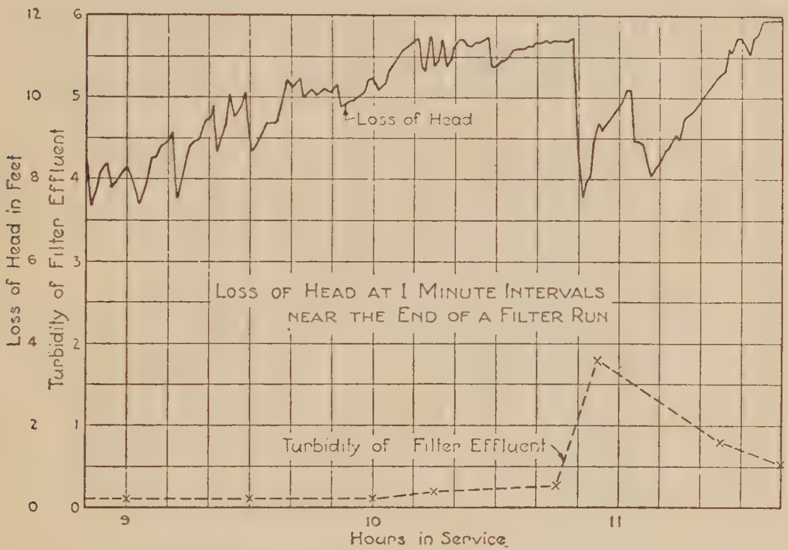


FIG. 16

This shows the loss of head was surging due to holes being forced through the surface layer of filtered coagulated matter, and to the formation of channels through the sand. The surging started at a loss of head of about 4 feet and was surging over 1 foot when the loss of head was about 5 feet. Due to increasing the rate of filtration and frictional resistances when a break occurs in so small a filter ($\frac{3}{4}$-inch diameter) the curve is not exactly typical of what happens in a large filter bed. There is probably a much greater surge at the point of break in a large bed.

between scrapings. Especially might it be applied at plants where the consumption of water requires maximum filtration rates, for it offers the possibility of increasing the rate without detriment to the quality of the water.

How suspended matter is removed by filtration. Perhaps a brief explanation of how filtration takes place in the ordinary rapid sand filter bed will give a clearer idea of what happens in rapid fine sand

filtration. We might say that rapid fine sand filtration is, to a certain extent, the reduction of all factors entering into the process of rapid coarse sand filtration. The particles of suspended matter are smaller, the pores through the sand bed are smaller, and the rate of filtration is lower. The filter beds, however, are not hydraulically graded, but Mr. Blaisdell claims there is some advantage in washing just a little of the fine sand to the surface.

If the removal of suspended matter is largely in the surface layer the loss of head will rise at an increasing rate somewhat as shown in figure 14. These curves are from an experimental laboratory filter, but the curve in figure 15 is from actual plant conditions when most

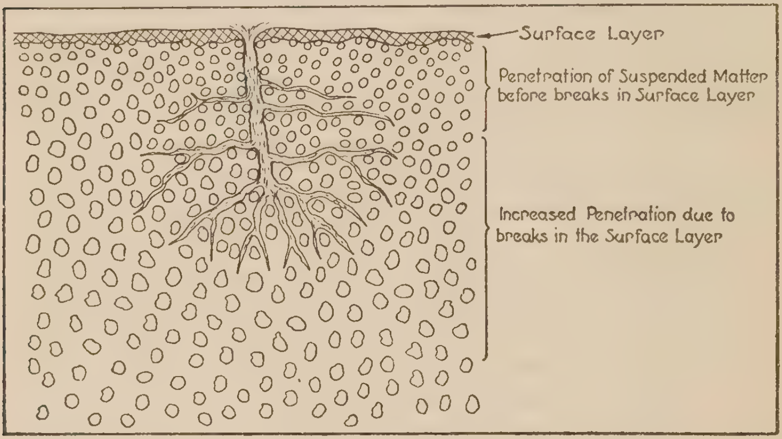


FIG. 17. PENETRATION OF SUSPENDED MATTER INTO A RAPID SAND FILTER BED

of the suspended matter was being removed in the surface layer. There is always some penetration of suspended matter into the beds under plant conditions and the curve does not increase in the rate of rise so rapidly as for the experimental filter where practically all filtration was in the surface layer. The increase in the rate of the rise of the loss of head is due to the suspended matter forming a compact film on the surface of the sand. Under most conditions the film does not build up tough enough to give a very high loss of head before it breaks. When breaks occur channels are formed in the upper layer of the sand, which tend to branch into smaller channels somewhat like the roots of a tree. At a depth of from $\frac{1}{2}$ to $1\frac{1}{2}$ inches the channels have branched so widely that the flow is only slightly in excess of the customary rate.

Immediately after the break the loss of head through the surface layer at the break has to be taken up by friction through the sand. Figure 16 shows the fluctuations in loss of head for a small $\frac{3}{4}$ inch laboratory sand filter after the head has reached a point where the suspended matter is being pulled below the surface of the sand. Should the difference in head through the surface layer be about 4 feet, it is readily seen that the water will rush through the break quite rapidly. Due to the limited area of the opening and the spreading of the water after it gets below the clogged layer, approximately normal rate of flow is reached in a very short distance. When the rate has slowed up to nearly normal, filtration begins to take place. This is illustrated in figure 17. The penetration of suspended matter into most of the sand beds, except where very coarse sand is used, is in this manner. There may be times in most plants when the water is cold, in which case most of the suspended matter penetrates into the beds and the filtration is largely by lodgement in the interstices of the sand and by attractive forces rather than by straining, but the prevailing manner is shown in figure 17.

In rapid fine sand filtration there is the same tendency, but due to most of the particles being much finer in proportion to the size of the pores through the bed, breaks, where there is considerable loss of head through the filtering layer, may result in some of the suspended matter passing the bed. It is largely for this reason that the rate of filtration has been made low for water which has not been coagulated. The reverse flow avoids sudden breaks in spots by opening up a large number of channels or pores over the entire bed. Then the loss of head is taken up by the control valve of the filter.

It seems that the method of filtration described by Mr. Blaisdell should be given careful consideration by those operating slow sand filters. Satisfactory drinking water should have the turbidity reduced to at least 0.5 parts per million. This is probably a lower figure than is being attained in many existing plants, but the trend is towards a clearer filter effluent and the merits of any new type of filter should be based on its ability to produce water which will meet this standard.

J. W. Ellms:[5] This paper describes the use of very fine sand in a filter bed of the general type used in slow sand filters. As the author

[5] Engineer of Water Purification and Sewage Disposal, Cleveland Water Department, Cleveland, Ohio.

advocates the use of reverse flow for the purpose of partial cleanings of the filter bed, he advises the installation of a carefully designed underdrain system capable of producing a uniform upward distribution of the wash water. For more thorough cleaning after prolonged periods of service, he uses his well known type of movable washer in which the sand is agitated by jets of water in a chamber lowered into the water and onto the sand surface to be cleaned. The dirty wash water is drawn off from the chamber and discharged into a wash water gutter provided for this purpose.

The efficiency of these filters lies, according to the author, in the very fine sand employed; i.e., sand with effective sizes ranging from 0.11 to 0.22 mm., and with uniformity coefficients varying from 1.5 to 3.9. As he claims that the efficiency of this type of filter is not related to the formation of a natural colloidal coating, created by bacterial action on the organic matter carried by the water, it would have been well to have shown the bacterial removals, or better the residual numbers of bacteria remaining in the effluent for a period of operation beginning with the starting of the filter containing the new clean sand and continuing for a period of five or six weeks. The usual type of slow sand filters and even rapid sand filters require a certain amount of "ripening" of the sand to produce the highest bacterial removals. It, therefore, is somewhat surprising that the author has found by merely decreasing the size of the sand that he is able to offset the efficiencies derived from a "ripened sand."

The relatively high rates of filtration employed and the losses of head resulting, even where turbid waters were filtered, are of considerable interest as indicating the possibility of using this type of filter on those natural waters which have generally been supposed as being more economically and efficiently purified by rapid sand filters using coagulants. It should be pointed out, however, that turbidities of filtrates ranging from 1 to 4 p.p.m. would not be acceptable to consumers who had ever been accustomed to a water entirely free from turbidity. The periodic "breaking" of the filter bed by reversal of flow, even though this is done at very low rates of rise of the wash water, is likely to produce slightly turbid effluents following the "breaking" operation. The more turbid the water being filtered is, the more likely the effluent will be slightly turbid.

The author states that these filters are very flexible, permitting the sudden increase in rates without impairing their efficiency. It has usually been considered that sudden changes in rates of filtration.

were likely to prove harmful, and should be avoided. However, with the filter bed composed of very fine sand, it may be that fluctuations in the rate of filtration within the ranges stated can be practiced without danger to the quality of the effluent. Detailed data on this point would be of interest.

The influence of entrained air on the loss of head in any type of filter bed is well recognized. In consequence, when starting a sand filter, it is customary to fill the bed slowly from the bottom in order that air may be driven out with the rising water. Any reversal of flow used by the author, after the filter has been operated for any period, would also effect the removal of air which may have accumulated in the bed. Air entrained near the sand surface would also be easily removed if the author's washing machine is employed.

The author attributes the high filtration rates which he employs, as compared with the rates generally used in operating slow sand filters, to the facility with which he can remove the entrained air from the bed. This explanation hardly seems necessary, since the use of higher rates of flow in the ordinary type of slow sand filter has not been prevented by an inherent difficulty in the passage of the water through the bed at greater velocities, but because these higher velocities produced poor grade effluents.

More detailed results of the operation of filters of the type advocated by the author will be welcomed by all those interested in water purification. There are undoubtedly some cases where the filtration of water without pre-treatment with a chemical coagulant, may be required, but it is not believed that such instances are at all frequent, or that in general the cost of such installations would be cheaper than a rapid sand filter plant of equal capacity. The writer cannot believe that there ever was or is ever likely to be a water purification plant either large or small, that does not require technical supervision. If the author has achieved this high degree of perfection in the operation of even small plants, the writer is open to conviction.

Allen Hazen:[6] This paper gives emphasis to the straining action of fine sand. Very fine sand acts like a Pasteur filter and practically removes from passing water all bacteria and other solid matters of corresponding size. This was known definitely at Lawrence from experiments made thirty years ago, as well as from many other experiences.

[6] Consulting Engineer, New York, N. Y.

With coarser sands the straining ability varies inversely with the grain size. The use of sand fine enough to act as an effective strainer for any small particles is certainly advantageous in filtration.

The advantages of fine sand have perhaps been often lost sight of in connection with chemical treatment and coagulation, used as preliminary processes, which, under favorable conditions, have permitted water of the desired quality to be obtained with only the moderate straining to be obtained with coarse sand. But as a broad proposition the fine sand will frequently accomplish what the coarse sand cannot. Considered in this way fine sand is always desirable.

The disadvantage of fine sand has been the difficulty and expense of operating with it. Partly because of its greater straining power and partly because of its greater frictional resistance the runs to be obtained with it are shorter and more washing must be done. This is true both of mechanical filters and of sand filters. These conditions have practically led to the selection of sands coarse enough to permit reasonable economical washing and operation, even though there was a sacrifice in efficiency.

Mr. Blaisdell has used his great ingenuity and skill in devising a means of washing fine sand in place in a filter in such a way as to make its use in filters more feasible and practicable. The demonstration of the results to be obtained in this way, surprising as they seem, are really but repetition of what was found in the early work at Lawrence, as Mr. Blaisdell points out.

It would seem that there might well be an increased use of fine sand in meeting American water purification problems.

On the other hand, it must not be overlooked that, even with Mr. Blaisdell's most ingenious devices, there remain practical problems that must be met and above all, it must always be remembered that a factor of safety to cover unusual conditions must be maintained.

Tests show that a certain rate of filtration under full control will produce sudden results, but in the actual operation of a plant other conditions than those met in the tests must be anticipated and, as a matter of practical experience, to insure that a plant will function year in and year out with full efficiency, it is essential that conservative allowances for rate and other matters be made.

The paper is thus to be recommended as bringing again emphatically to our attention the advantages in the use of fine sand, and it is certainly worth our while to strive for these advantages as far as they can be secured without sacrificing other operating conditions.

APPLYING CEMENT LINING BY CENTRIFUGAL MEANS TO CAST IRON AND STEEL PIPES

By Donald Moir[1]

Early in the year 1923, the Directors of the Consolidated Water Works Company of Rosario de Santa Fé, Argentine Republic, in view of the trouble experienced from corrosion and tuberculation of their distribution system, decided that all extensions and renewals should in the future be laid with cement-lined pipe, the lining to be applied centrifugally with the object of assuring both its impermeability and its rigid adhesion to the metal.

Because of the limited number of manufacturers then in a position to supply centrifugally cement-lined pipe, full advantage could not be taken of trade competition to purchase pipes under the most favourable conditions. Furthermore, the extra freight charges on the weight of the lining combined to raise the price of these pipes considerably above that of the unlined variety.

It became evident, therefore, that, if a convenient process could be devised, whereby lining operations could be carried out on the spot by the Company, the extra freight charges mentioned would be eliminated and purchases of the unlined pipes could be made in the open market.

Essential features of any such process had of necessity to be: (1) low capital cost of the installation; (2) adaptability to a wide range of pipe diameters, and (3) economical results. The process ultimately decided upon, and developed, consists of applying to a pipe, into which has previously been introduced a measured quantity of semi-liquid cement mortar, a rotary motion by rolling down a suitable incline under the action of gravity, and of utilising the centrifugal force thus generated to project and consolidate around the interior of the pipe wall a uniform layer of the cement mortar referred to.

In actual practice at Rosario, two sets of parallel rails are laid on

[1] La Compania Consolidada de Aguas Corrientes Del Rosario, Rosario de Santa Fé, Argentine Republic, South America.

sleepers placed on the ground. Two of these rails are spaced at 9-foot gauge, and are utilised for coating pipes of the smaller sizes rolling upon their own circumference. The other two rails are spaced at 14-foot gauge, and deal with larger diameter pipes rolling upon end trunions of smaller diameter than that of the pipe.

It will be observed from the accompanying profile sketch in figure 1 that the track is made up of 3 sections of different grades. The first section "a b" is arranged, with respect to length and slope, so that a pipe starting from "a," and rolling to "b" will, upon reaching the latter point, have acquired a predetermined rate of rotation, while the grade of the second section "b c" maintains approximately constant this rate of rotation between "b" and "c." The upward inclined section "c d" simply acts as a brake and brings the pipe again to rest.

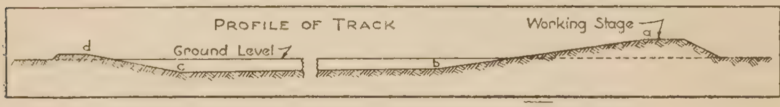


FIG. 1

A pipe placed at the point "a" possesses with relation to the point "b" a potential energy equivalent to WH foot pounds, where W = the weight of the pipe in pounds, and H = vertical height in feet between "a" and "b."

Upon rolling down to "b" this potential energy becomes converted, after deducting that spent in overcoming friction and windage, into what may be termed directional energy and rotative energy. It can easily be shown that in the case of a pipe rolling on its own circumference the value of the rotative energy is in all cases somewhat less than that of the directional energy. As only the former is of value in generating the centrifugal force required to effect the lining operation, it is desirable to increase the rotative energy at the expense of the directional energy. This can be accomplished in an exceedingly simple manner by providing rolling members of small diameter which may take the form of a steel tube passed through the pipe and projecting at each end a sufficient distance to rest and roll upon the rail track, the pipe being supported concentric with the tube by means of suitable end flanges attached to the latter. By this arrangement, a track which is only of sufficient length for lining small size pipes rolling upon their own circumference, can likewise be utilised for comparatively large diameters.

The pipes to be coated are placed on the horizontal at the top of the slope "a b." Here suitable end stoppers are fitted on; a measured quantity of semi-liquid cement mortar is poured in from either end through holes provided for the purpose in these stoppers; directional members in the form of taper cones are placed on the body of the pipe, if of small diameter, or on the end trunions, if of large diameter, with the object of correcting any tendency to derail; and the whole is then rolled over the edge of the slope "a b."

Under the action of gravity the speed of the pipe accelerates on its journey from "a" to "b." Throughout the first few yards of rolling the rate of rotation is, however, insufficient to throw the mortar outwards, and this therefore remains on the underside of the

TABLE 1

Cast iron pipes lined with cement to January 31, 1926

DIAMETER	METERS LINEAL
inches	
4	52,782.84
6	10,738.66
8	2,300.02
9	208.00
10	3,244.00
12	3,615.48
15	4,282.20
20	2,291.16
24	589.26
30	2,382.66

pipe and becomes distributed in a layer of uniform depth along its length. As the speed increases, a point is reached where the mortar becomes projected by centrifugal force against the pipe wall, forming a layer perfectly concentric with the axis of the pipe, while further increase in speed causes the excess water to be displaced towards the interior by the solid constituents of the mortar, because of the higher specific gravity of the latter. By maintaining the maximum velocity from "b" to "c" further displacement of the water, with a corresponding consolidation of the mortar, is effected and, upon the pipe being brought to rest by the stopping incline "c d," the excess water is run off, leaving a compacted and impermeable layer of mortar, smooth in surface and firmly adhering to the metal of the pipe. The end stoppers and directional members, previously referred to,

are then removed and, after a period, the length of which depends upon climatic conditions, the pipe is rolled into a water bath where it remains at least 24 hours, for the purpose of avoiding a too rapid drying of the mortar.

The process is admirably adapted for the use of municipal or private water undertakings that may, for reasons of economy, desire to carry out lining operations on site, and for their own account. Not only are they thereby enabled to protect all new piping from the ravishes of corrosion, but, at the same time, old piping which has become inadequate because of reduction in diameter from tuberculation, can be taken up, cleaned, coated and relaid, thus restoring its initial carrying capacity and securing, at comparatively little cost, what is practically equivalent to a new pipe. This latter facility will be appreciated by those who have to deal with distribution systems in which, because of the nature of the water conveyed, the incrustation problem has assumed serious proportions.

The first cost of the installation is exceedingly low, especially where ground is available possessing natural contour features approximating to the grade required, while not the least of its advantages is the elimination of a source of power for operation.

Since its adoption by the Rosario Water Works Company in June 1924, the lengths of new and old piping of the various diameters stated in table 1 have been successfully treated. The average cost based on a unit of 1 inch diameter and 1 metre length has worked out at $0.067 argentine paper, including all charges with the exception of depreciation and interest on capital, which are so small as to be practically negligible.

Any desired thickness of lining can be applied, and the practice followed here has been a thickness of $\frac{1}{16}$-inch on 4-inch pipes, gradually increasing to $\frac{3}{8}$-inch on 30-inch pipes, the mixture employed being 1 part of cement and 1 part of clean sand.

No difficulties have been experienced with the lining breaking away when drilling and tapping the pipes to receive the ferrule of the house connections, and even when cutting the pipes with a cold set and sledge hammer, fracture of the lining is found to coincide with that of the metal.

Rosario draws its domestic supply from the river Parana, the waters of which, being soft and exceedingly aggressive, rapidly build up tuberculation in the mains, with the corresponding falling off in capacity. Samples of centrifugally cement-lined pipe, which have

been removed for inspection after a period of service of $1\frac{1}{2}$ years have, however, been found to be perfectly clean, while neither the lining nor the metal shows the slightest sign of being affected.

Without being unduly optimistic, therefore, the author believes that a means has been found whereby water authorities, at a trifling cost, can effectively protect their mains and distribution systems against attack by soft or aggressive waters, and, at the same time, assure that the initial capacity of these will be maintained by prohibiting the formation of tubercles.

The process is equally adaptable to the application of protective linings of materials other than cement, or cement and sand. Asphaltic compositions, when put on in this manner, are entirely free from the minute pin hole defects always present in dipped coatings, through which the water penetrates to carry on its attack on the metal. In cases where this class of lining is preferred, its application centrifugally removes the most serious objection to its use.

FINANCING WATERWORKS PROJECTS[1]

By C. N. Phillips[2]

It is my intention to discuss the financing of waterworks projects from the standpoint of several years experience as a dealer in municipal securities. Theoretically two methods of financing are open to a municipal corporation desiring either to construct a water system, purchase a water system, or make substantial improvements or extensions to a system it already owns. These two methods are the payment of the cost from current revenues or by borrowing on the credit of the municipality through the medium of long time municipal water bonds. Practically speaking, in almost every instance the capital expenditure required is too great to be paid out of current revenues and I shall, therefore, deal with the financing of such projects by the issuance of municipal water bonds.

Municipal corporations have authority to issue bonds only as such authority is specifically granted by statute. The laws of the various states outline in detail the necessary steps to be taken, usually specify the maximum rate of interest such bonds may bear and contain certain restrictions as to the maturity of the bonds, price at which they may be sold, etc. In the three states of Colorado, Wyoming and New Mexico, there is a very wide divergence so far as certain features of these laws are concerned. I shall not bore you with a detailed résumé of these laws, but shall endeavor to outline certain principles and methods of precedure which it seems to me should be followed out as nearly as may be under the legal restrictions imposed by these laws. In so doing, I will have occasion to mention some of the outstanding features of these laws which must be taken into consideration.

When a bond issue is contemplated the first thing, naturally, to be determined is the maximum amount of bonds to be authorized. So far as this is concerned, we have no legal restriction in any one of

[1] Presented at Conference of Water Superintendents, Rocky Mountain Section, February 23, 1926.

[2] Jas. H. Causey Co., Investment Bankers, Denver, Colorado.

these three states, as their constitutions specifically exempt waterworks bonds from the operation of debt limits imposed for other purposes. This is also the case in most of the states throughout the country. There is good sound reason for this, particularly in the West. A good water supply is, of course, the most important requisite to a community of any size and in the West it is often necessary for municipalities to incur, and rightly so, a heavy amount of indebtedness in order to secure an adequate water supply. There is another reason for exempting the water debt from the operation of a debt limit and that is the fact that the revenues from the operation of the plant should, in addition to operating and maintaining the system, contribute substantially to the amount of money required for principal and interest on outstanding bonds, which I shall refer to as debt service. Of course, there is this to be said, except in certain very small communities where it would be impossible to charge a sufficient rate for water to provide all of the necessary funds and it is consequently imperative to depend partly on taxation, the question of whether this money comes from water sales or taxation is principally one of policy and bookkeeping.

Therefore, as to the amount of indebtedness which may be incurred, a municipality is limited only by the amount the taxpayers are willing to authorize and its ability to sell its bonds. It seems to me that public officials contemplating a bond issue for water works owe it to the taxpayers of the community as a first step to obtain adequate and competent engineering advice as to the original cost of a project and also the operating cost after it has been constructed, so that the taxpayer can be fully informed and exercise a really intelligent decision when he goes to the polls to vote on a bond issue. The taxpayers are entitled to this information, because in the final analysis municipal water bonds are secured by the taxing power of the municipality and not by the earnings of the water system. An ample amount should be included because any municipality has authority to issue a less amount of bonds than have been voted if the entire amount is not needed.

Outside of the duty to the property owners, our New Mexico friends find it practically imperative to know how much they will need when they start, because in New Mexico a bond issue can be submitted at regular municipal elections which occur only every two years and so it is extremely important that sufficient funds be provided in advance to complete any project which is undertaken.

In Colorado municipal officials have much more lee-way. In fact municipal officials in Colorado are given more authority in this respect than in any other State with which I am familiar. When an election has once been held in a municipality in Colorado and the erection or purchase of a water plant has been authorized by the taxpayers, the city council or board of trustees has power and authority, without again going to the voters, to issue whatever amount of bonds may be necessary in their judgment, such action, of course, being subject to the referendum. Wyoming requires an election for each bond issue, but permits the calling of special election at any time for the submission of water bonds to the voters.

With the amount of bonds determined, the next step is to arrange what we call the "set-up" of the issue, meaning the maturity, provisions for payment, rate of interest, etc. Modern practice has demonstrated that there are recognized principles of sound finance which should be applied to municipal affairs as well as to private business as far as possible. I believe the greatest evil in arranging municipal bond issues has been the tendency to postpone for too great a period the payment of the debt. In the matter of the maturity of municipal bonds and the method in which they are paid there has been much progress. The best thought on the subject of municipal finance requires that the term of a bond issue shall not exceed the life of the improvement, so that the burden of the improvement will not have to be borne by people who do not enjoy its benefits. In some of the eastern states where new bond laws have been enacted in recent years, provision is made that the maximum life of the bonds shall not exceed the life of the improvement, such life to be determined in some cases by statute and in others by the certificate of an official such as the city engineer. In arranging the manner of paying these debts, we have come to appreciate the great advantage of the serial or installment bond, as opposed to the old sinking fund bond. In the case of a serial bond issue no sinking fund, with its attendant possible abuses, is necessary, as provision is made each year for the exact amount of bonds maturing that year. As the principal of a serial bond issue is paid the interest is reduced each year the full amount of such payment, whereas, if the same amount of money were credited to a sinking fund it could probably not be invested to draw as much interest as the bonds carry. There are two plans of serial payment, one is to arrange a bond issue to mature in substantially equal amounts through a given period of years. Under this plan

the heaviest charge for debt service comes at the start. The second is what we call the "level tax plan" where the amount of principal due is increased periodically as the interest is reduced.

Theoretically a correctly arranged municipal bond issue should be paid in serial installments starting at the time the bonds are issued or very shortly thereafter and continuing through a reasonable life of the improvement. The laws under which waterworks bonds are issued in the three states we are considering were all passed a number of years ago before much consideration or thought was being given to these principles and in operating under them we find ourselves rather seriously handicapped.

The Colorado law, for instance, requires a water bond issue to be paid off within 15 years, but does not permit any of the bonds to be due in less than 10 years and does not require any provision for a sinking fund during the first 10 years. The Wyoming law provides for bonds running 30 years, but optional at the end of 15 years. It does not require any provision for the payment during the first 15 years. The New Mexico statutes allow a maximum maturity of 50 years, requiring bonds to be optional after 20 years. This statute does permit a serial bond issue so that in New Mexico a bond issue can be arranged as to maturity in accordance with the above principles, but it is not compulsory to do so.

It can be readily seen that under all these laws there is a long period of the best usefulness of the water plant during which time a municipality is not required to make any provision for the payment of the debt. In Colorado, particularly, the maximum maturity of the original bond issue is so short that most waterworks issues are refunded at the end of ten or fifteen years and usually without any reduction in the amount of the issue. The Colorado refunding law, fortunately, contains the benefit of more modern experience and it is compulsory that refunding bonds be paid serially. It is to be hoped that these laws will be re-enacted in the near future to incorporate the benefits of present day experience and practice.

The rate of interest is best determined by authorizing, when the bonds are voted, the maximum rate allowed by law and then determining the most advantageous rate when the bonds are sold. The next step is the securing of adequate and competent legal advice.

Modern practice among bond dealers requires that all bond issues be approved as to legality by a firm or attorneys who are known as experts in this line. Either through the agency of bond houses or by

municipalities getting directly in communication with such bond attorneys, their services can be secured for a reasonable fee to direct the procedure for any bond issue. On this point I take the liberty of quoting from a recent editorial from the Bond Buyer, the leading municipal bond journal. Commenting on inquiries they receive as to the advisability of this service, they say:

Invariably our advice is to have a recognized firm of bond attorneys not only write the approving opinion but also supervise the proceedings from the start. A municipal bond issue which does not carry with it the opinion of one of these recognized bond attorneys is not readily salable and, therefore, the municipal bond dealer must secure this opinion at his own expense, if the issuing municipality has not seen fit to arrange for it prior to the public offering of the issue.

In view of this situation, it follows that dealers bidding competitively for a bond issue, if advertised as carrying the opinion of these recognized attorneys, which opinion is to be paid for by the issuing municipality, will, in effect, add the cost of the opinion to the price which they offer to pay for the bonds, since the payment of the attorney's fee by the municipality clearly relieves them of one of the usual expenses which is incurred in handling a bond issue.

Aside from the simple question of the cost of the opinion it seems to us there are other advantages accruing to a municipality which arranges in advance of its bond offering for the favorable opinion of a municipal bond attorney.

First, to have the proceedings leading up to an issue supervised by one of these bond legal experts virtually precludes the chance of making some technical error that might invalidate the issue and lead to repassage of ordinances and resubmission of an issue to the voters, readvertising of an offering of bonds or some other duplication of effort and expense.

Secondly, when the prospective buyers of an issue are assured that the favorable opinion of a recognized municipal bond attorney has been arranged for in advance, the dealer is assured that upon the award of the issue to him there will be no unusual delay in delivery of the bonds resulting from technical legal difficulties. This is most important because the dealer must always consider the possibility of fluctuations in the bond market. Unless he can resell the bonds to his clients quickly, his risk of having the market turn against him is considerable and he must take all of this into consideration in estimating the margin of profit to which he is entitled in handling the bonds.

It will be readily apparent that, particularly in New Mexico, with one bond election possible only once in every two years, a legal error in connection with such an election would be very serious. To my personal knowledge several of the larger cities in all three of these states already employ expert bond advice whenever they contemplate the issuance of bonds.

All of the suggestions which I have made so far have had to do with steps to be taken prior to the voting or authorization of bonds. When the preparatory work has been done in this way, the sale is a comparatively simple matter. There are two methods of bond sale, namely: public and private. Technically speaking a public sale is a public opening of sealed bids received after advertisement. New Mexico is the only one of the three states requiring by law public advertisement of water bonds. Here notice must be published for thirty days in a New York paper, a Santa Fé paper and a local paper. In Colorado and Wyoming the method of sale is left to the discretion of the municipal officials. In these states very often the sale of the bonds and the securing of proper legal instruction and competent advice as to the set-up of an issue are obtained all in one operation by selling the bonds prior to and subject to the election or authorization. Ample competition is obtainable by a short notice sent to a few houses known to be interested. On the other hand, where greater publicity is desired either the bond attorneys or bond houses are ready and willing to give municipalities the benefit of their knowledge and experience in helping them to prepare correctly a proper set-up for a bond issue.

One of the most common provisions in municipal bond statutes throughout the country is, or more correctly was, a provision requiring the bonds to be sold at not less than par, evidently inserted to prevent municipal officials from making an unfavorable bargain, and it is not uncommon to find both a maximum rate of interest and a provision that bonds must be sold at par. This applies both in Wyoming and New Mexico and every now and then a combination of circumstances results in a given municipality not being able to obtain par for bonds carrying the maximum rate of interest. When this condition exists, it is necessary either to hold up the project or evade the law.

Municipalities, without exception, can obtain a cheaper net borrowing rate on their bonds if they will, when permitted by law, sell at a slight discount. This enables the bond house to buy the bonds at a price so that it in turn can sell them to the ultimate investor at par and almost without exception investors will accept a lower rate of interest at par in comparison with a somewhat higher rate when they have to pay a premium.

I have been endeavoring to emphasize that the really important steps of a bond issue are the preliminary steps which are often given

the least consideration. Give your taxpayers ample information upon which to vote intelligently; take advantage of the services of bond attorneys and the bond houses in getting the most scientific set-up, particularly as to maturity and obtain the best possible legal service. If you let these matters go until the bonds have been voted and are ready for sale, it is often too late to adopt suggestions which obtained earlier might have been of great benefit.

PRECISE TURBIDITY READINGS BY ELECTRICAL METHODS[1]

By Leroy H. Scott[2]

The machine is so designed as to read all turbidities of the raw influent water into the plant. One is able then with only a glance at the pointer to tell the exact condition of the raw water.

The machine depends upon its action by the variation of light on a photo-electric cell. This cell is so made that the resistance will vary in direct proportion as the square of the power of light thrown on it. The variant light is made by passing light through a column of water. As the turbidity changes the light on the cell will vary accordingly.

The machine consists of only four parts, an ordinary electric light, water tube, photo-electric cell and an extremely sensitive galvanometer. Both ends of the water tube are sealed with a convex lens, both focusing in the same direction, that is, the lower one focuses into the water tube and the upper one on to the plate of the photo-electric cell. Water is made to circulate in at the bottom of the tube, through the tube and out at the top, keeping it entirely full, due to the rise of the effluent. At the bottom of the tube, under the lower lens is placed the electric light. At the top is placed the photo-electric cell in a light-tight compartment, and so arranged that the light from the tube will focus on the plate of the cell. It will be seen then with this arrangement that, as the water gets slightly turbid, the intensity of the light on the cell will vary. This varies the resistance in the cell, and this variation is recorded directly on the galvanometer, which scale is calibrated to be read in turbidities.

Some idea of just how sensitive the cell is can be appreciated when it is found that with a change of 0.16 foot candle of light there is a change of 60 micro-amperes, or a deflection of fifteen on the scale reading. These cells are made so that there is very little lag in response and the resistance is constantly the same with the same variation in light.

[1] Presented before the Illinois Section meeting, March 25, 1926.

[2] Chemist-in-charge, Delaware Filtration Plant, Delaware, Ohio.

A machine to be used on the filter effluent water is under construction, and it will vary from this machine only in that as the water gets turbid, it will trip an amplifying relay, closing a circuit and sounding an alarm on the operators floor calling his attention to that filter. The relay is adjustable and can be set to sound the alarm with a change in turbidity hardly noticeable to the eye.

It was found in experimenting with this machine that, when the water tube is filled with clear water, the whole acts as a thick convex lense, thus concentrating the light on the cell more than when the tube is empty. If the filter should get air bound or for some reason is not filtering any water, the alarm will sound, in the same way as if the filter were in a dirty condition.

THE BUSINESS SIDE OF PRIVATE FIRE PROTECTION[1]

By Dow R. Gwinn[2]

Private fire protection is service of a special character, not enjoyed generally but by a comparatively small number. It is a valuable service and as stated by a supreme court, "a standing guard over property against the peril or destruction by fire." It is a readiness to serve proposition.

There should be no confusion between private and public fire protection. They are as distinct as public police protection and private watchmen service.

A manufacturer who wants additional police or watchman service other than that which is furnished and paid for from public funds hires and pays for such watchmen as he needs or wants. A city would have no right to pay from public funds, except in case of an unusual emergency, for the services of a watchman on privately owned premises.

And on the same principle, a manufacturer who desires fire protection for his private property in addition to that which is enjoyed by the public in general, a service which gives him more than his neighbor is provided with, should pay for that service. The manufacturer should pay for special private fire service as he pays for special watchman or private police service.

Each class of consumers should pay its share of the cost of providing water service, and the small or domestic consumer has a right to complain where only a nominal charge is made for large connections for private fire protection.

It might be said that large connections for automatic sprinkler service do not cost the municipality anything, as the manufacturer pays for the inside pipes and equipment.

The National Board of Fire Underwriters, in their report of the Fire Prevention Committee (1911) on the City of Terre Haute, Indiana, under the head of "Protection," stated, "Reasonable protection for

[1] Presented before the Louisville Convention, April 28, 1925.

[2] Terre Haute, Indiana.

the principal mercantile district requires a fire flow in excess of maximum consumption of 6500 gallons per minute, with a system capable of delivering this amount about any block and hydrants so located as to deliver two-thirds of the quantity upon any large fire through nose lines, none exceeding 500 feet in length. The total quantity includes an allowance for losses from broken services, elevator and sprinkler connections incidental to a large fire and should be available at pressures sufficient to give direct hydrant streams."

Reports on other cities have also contained similar requirements. Now, if a water works plant, owned either by a municipality, or a company, having equipment sufficient for ordinary demands and fires, is required to have larger mains and other equipment to provide for service for automatic sprinklers, including the bleeding of mains when a large connection is broken, due to the falling of walls when the sprinklers fail to extinguish the fire, *why* should not such service through large connections be paid for by those who enjoy this unusual and valuable service with consequent saving in insurance premiums?

Let those who enjoy unusual and special service pay for it, if furnished at all.

Personally, the writer questions if such service should be furnished by means of large connections to public water mains. First: According to report of Committee on Private Fire Protection, (see Journal American Water Works Association, November, 1919) public water supplies in over a dozen cities have been polluted from independent fire service supplies through private fire service connections. Among the list are the cities of Lowell, Mass., Rockford, Ill., and Elgin, Ill. In the latter city an epidemic of typhoid, attributed to a dual private fire system, resulted in 18 deaths. An epidemic of typhoid in Logansport, Ind., 1924, was blamed on a dual connection between the City supply and that of a Railroad Company, resulting in 22 deaths. After this occurrence the Indiana State Board of Health issued an order prohibiting cross connections between city supplies and independent plants where the source of such independent supply was surface water.

Second: The danger of bleeding of public water supplies where the automatic sprinklers fail to extinguish a fire and the pipes are broken when the walls fall allowing enormous quantities of water to run to waste. It is almost impossible for an average direct pumping plant to maintain proper pressure and supply when, in addition to the ordinary demands for domestic consumption and uses by the fire

department at a large fire, a 4 or 6 inch connection is discharging at full capacity into the air. See report in Journal American Water Works Association November, 1919, of 15 cases of bleeding of water mains due to broken fire service connections.

Large connections for automatic sprinklers are a menace to the general or public fire protection. The writer is of the opinion that the time is coming when the Underwriters will be opposed to such connections for that reason. Perhaps the most serious case on record of the bleeding of water mains due to broken sprinkler connections was the Salem, Mass., conflagration in 1914. (See the Eng. News, Oct. 22, 1914, page 830, and Nov. 19, 1914, page 1035.)

F. A. McInnes and Clarence Goldsmith, then of the Boston Water Department, were present and furnished the report. To quote from this report:

> The two buildings (Chas. H. Keefe Plant and Carr Leather Co. plant) ignited immediately and a large number of sprinkler leads opened in a very short time, but were powerless to check the fire. The collapse of the buildings resulted in the breaking of the sprinkler pipes, allowing the capacity of the three large connections to be wasted from the 20-inch main. . . . .
>
> The lesson to be learned from the experience in Salem is that the existence of connections from a distribution system of such size that their failure destroys the pressure at the hydrant is a mistake that surely invites disaster to water works systems and doubly so on depending upon hydrant hose streams.
>
> The record of fires occurring in sprinkler risks during the past sixteen years shows that in a total of 14,253 fires, 13,691 were controlled by the opening of less than 51 sprinklers and only 662 or 4.6 per cent were not controlled by this number of sprinklers, which number can be supplied by a 4-inch connection.
>
> We are absolutely of the opinion that the flow of water through the connections to the Keefe and Carr plants practically destroyed the efficiency of the Salem Water Works system and are convinced that the size of such connections should be carefully restricted.

Evidence such as this is most convincing, especially as it is from two engineers of such high standing in the water works field.

Perhaps it would be the part of wisdom of water works superintendents to ask themselves if they are inviting a conflagration like the Salem one, or a typhoid epidemic like the one at Elgin, Ill., or Lowell, Mass.

In the proceedings of the Indiana Sanitary and Water Supply Association for 1916, page 104, W. S. Cramer, Chief Engineer of the Lexington, Ky., Water Works, and past President of this Association, is quoted as follows:

I cannot see any reason why any water works official should sanction any connection with a water system from any other source of supply. It is not a question of a check valve, or a dozen check valves, and it does not make any difference how many check valves you have, you still have the possibility and the hazard of pitting a human life against the saving of a few dollars, and it seems to me it is an outrageous proposition. I do not think the water works men ought to allow any connection of their water mains with any other source of supply.

On page 105 of the same proceedings Dr. W. F. King, now Secretary of the Indiana State Board of Health is quoted, as follows:

I think Mr. Cramer has struck the meat in the cocoanut. I have heard check valves discussed and various sorts of makeshifts or contraptions so to speak, to protect the water supply from an auxiliary water supply. It seems to me that the only reasonable and safe way to handle the proposition is to absolutely have a water supply that is intended for human consumption separate and distinct from any other source of supply. We have had several instances of that sort in this State (Indiana), one at Shelbyville a few years ago. The result always goes to prove that there is no absolute safety unless the water supply intended for human consumption is separate and distinct from any other source of supply.

It is not necessary in every case to have connections with a public water works for automatic sprinklers. The protection may be provided by independent or local equipment such as a cistern, fire pumps and elevated tanks. There is in Terre Haute a large wholesale grocery concern with several large buildings, one being seven stories in height, that is equipped with automatic sprinklers which has no connection with the public water system. In that case they pay the actual cost of it, including interest on the investment, depreciation, repairs, taxes, fuel used in maintaining steam, extra labor in looking after the pumps, and also additional labor on Sundays and holidays, and at such times as the factory may be shut down. An insurance expert estimated the cost of such private fire protection when furnished by the manufacturer, in one case to be approximately $600 per annum.

Why should large connections which are a menace to the health and general fire protection of a city be allowed? The writer would prefer not to assume the responsibility. However, if connections are allowed they should be restricted where the street mains are large enough to *four inches* in diameter, *should be metered through a fire-line meter and independent of all other supplies.* And *they should be paid for.*

The Indiana Public Service Commission in the Terre Haute Water Works Company case (1915) stated:

> There is no perceptible reason why the water company should be compelled to provide and maintain a sufficient supply of water to operate the water sprinklers in time of fire for private individuals without compensation. On the contrary, this special benefit to the property owner over and above what the municipal fire protection affords the people in common, should be paid by the private user.

The minimum meter rate should be based on the rated capacity of the fire meter in proportion to the minimum rate charged for small house meters and their rated capacity.

For instance, if the minimum monthly rate for house meters with a capacity of 15 gallons per minute is $1.00 and the fire meter has a capacity of 150 gallons per minute, then the minimum monthly rate for the latter should be ten times greater or $10.00 per month. However, the insurance interests would want a larger supply than 150 gallons per minute; if so, the rate should be in proportion, because the demands are greater, and a larger plant and equipment are necessary.

The savings due to automatic sprinklers in insurance premiums amount in some cases to $3000 per year. In one case where $300 per year was paid the water company for fire protection, there was an actual saving of $1120 per year after allowing for interest and also depreciation on equipment.

All the water department or company has to sell is water and fire protection service, hence automatic sprinkler service should be paid for. The payment by a city of public fire hydrant rental does not cover private fire protection service.

REFERENCES TO COURT DECISIONS CONCERNING PRIVATE FIRE PROTECTION

The principal object of the defendant's water board in requiring fire service pipes to be metered is to prevent the surreptitious or careless withdrawal of water through such pipes for other purposes than the extinguishment of fires; another object is to procure the measurement by meter of all water consumed for any purpose in order to check wastage and to require each taker to pay for the exact quantity of water furnished by him.

Both upon principle and authority we are of opinion that under circumstances like those before us it is not unreasonable to require the installation of a meter at the plaintiff's own expense in its private fire service pipes.

Nor can it be said that this regulation imposes undue burden upon the plaintiff. The defendant has afforded reasonable means of extinguishing

fires by public hydrants; if the plaintiff desires in addition a private system for the protection of its own buildings, it is not unfair for the defendant to impose, as a condition of supplying without other charge, water to make this system available, the requirement that the plaintiff shall take this water only through a meter to be put in at the plaintiff's expense.—*Shaw Stocking Company v. City of Lowell (Supreme Judicial Court of Massachusetts; Middlesex. May 22nd, 1908. 85 Northeastern Reporter, 90).*

The proprietor of a building, who installed therein an automatic sprinkler system, intending thereby to put out fires before they could gain headway, derives benefit for the system in fire protection and reduced insurance rates, and though there be a general benefit in reducing fire hazards, yet a municipal water works system to which the sprinkler is attached performs a service, and stands ready to perform others for which charges may be made.

It is evident that payment for the small quantity of water used would be wholly inadequate as compensation for the pressure required, and the readiness at all times to serve and the inspection of the city which might well be exacted.—*Edgerly vs. City of Ottawa, 156 N. W. 388, decided Feb. 1916, by the Supreme Court of Iowa.*

Action to restrain city from placing a meter on fire extinguishing plant dismissed by Appellate Division of the Supreme Court. Judgment affirmed with costs.—*American Mfg. Co., Appellant, vs. City of New York. Court of Appeals of N. Y. January 27, 1911.*

A water company which supplies the pressure and water for an automatic sprinkler for a private corporation performs a service which is not included under its contract with the city to supply water for fire protection and has the right to make a reasonable charge therefor against the corporation.—*D. B. Loveman Co. vs. City Water Co., 1 Tenn. Ch. App. 596.*

In the matter of furnishing water to its citizens, a city when authorized by its charter acts in a private rather than a governmental capacity and has the same right to make reasonable charges therefor that a private corporation has when serving the public.—*St. Louis Brewing Ass'n vs. City of St. Louis, 140 Mo. 419—37 S. W. 525, 41 S. W. 911.*

A rule, providing that water meters might be installed at the pleasure of the water board on the consumer and that after they had once been installed, the consumer could not thereafter return to the flat rate, is reasonable and may be enforced where the meter rates are reasonable and no discrimination between consumers is shown.—*Powell vs. Duluth 97 N. W. 450.*

The law imposes no duty to insure the property or extinguish fires.—*Woodberry vs. Tampa Water Co., 57 Fla. 243, 49 So. 556.*

The Arizona Commission in fixing rates to be paid to a water company, decided that a mining company desiring a private fire protection system, should be required to pay a fixed demand charge although "the actual water consumed for this purpose is likely to be negligible.—*Arizona Corp. Com. vs. Morenci Water Company, Public Utilities Reports, 1915, C 525, 527.*

A great deal has been written upon the subject of charges for private fire protection, such as service for inside private hydrants and sprinkler systems. It seems to be the consensus of opinion of operators that a minimum charge is entirely reasonable based on the idea of the "ready to serve" proposition. It is

obvious that a manufacturing establishment or other business installs such private fire service equipment for the special security of its own property over and above the protection undertaken by the water company for the benefit of the public. For this reason it might be equitable to assess some charge for this service varying with the size of the connection. In the present instance, it appears that the water utility will be justified in metering all services installed for the purpose of such protection, not with the idea of charging for water used in case of fire, but for protection against surreptitious use as close inspection and supervision have been found in many cases to be inadequate.—*Beloit, Wis., vs. Beloit Water, etc., Co., Public Utility Reports, 1915, B.p.1005, 1020.*

The benefit derived was not incidental, but it was the result of a direct appropriation by the furniture factory of power and water, which was the property of another, as a standing guard over its property against the peril or destruction by fire. Connection with a light or water plant accompanied by the asserted right of using it and the means of exercising the right is a benefit enjoyed at the hands of another imposing an obligation to make reasonable compensation although the occasion for actual use never arises. Here there was not only the connection, the asserted right to use it and the means of exercising the right affording continual protection against fire, but there was a positive saving of insurance bestowed upon the furniture factory by the water company. The fact that there was no use, no actual consumption of water, is a factor to be considered in estimating what should be the amount of compensation, but it does not relieve the furniture factory from liability for the fire protection furnished at the expense and labor of the water company.—*Cox v. Abbeville Furniture Co., 54 S. E. 830.*

So long as water supplied for protection against fire is a purely public service, under the control and management of municipal authorities generally, and under the fire department specificially, no direct charge to individuals is proper. When, however, a sprinkling connection is made with private premises the situation is materially different. These premises and the primary causes of catastrophe to the building and of the consequent possible use of disastrous quantities of water are primarily under the control, not of the public, but of the owner. A peculiar personal service is provided for his benefit, which is not enjoyed in common by the community in general, but is available only to a limited class of individuals. It does not advance the reasoning in this connection to split hairs between the "use" and the consumption of water. As a matter of good sense the property owner beneficially employs the water mains for his own purposes and to his own advantage, although he may not, except in case of fire, actually draw any water from the pipes. It is necessary and proper that for this he should pay. In effect he gets something of pecuniary value from another, which that other is not compelled to give except on the basis of contract. That the law required the terms of that contract to be reasonable and impartial or that advantage is mutual and involves no expense, is merely incidental or collateral. The conclusion is reached that a charge can be made. How great that charge should be in the view here taken is not before us.—*Gordon v. Doran, S. L. R. A. (N. S.) 1049. (The same case is reported in Ill., N. W. 272.)*

REACTION OF ORTHO-TOLIDINE WITH SURFACE WATERS

By Ole Forsberg[1]

The ortho-tolidine test for residual chlorine, because of its simplicity and rapidity, is a valuable aid, and in many instances the only method used, in controlling the chlorination of water supplies. In communities where chlorine sterilization is employed, and where facilities for regular bacteriological examinations are not available, the ortho-tolidine test is used to determine the efficiency of the treatment. Any physical or chemical property of the water which vitiates the reliability of the test seriously affects the quality of the water produced under these conditions.

The writer's attention was called to the discrepancy between the apparent and true ortho-tolidine reaction with chlorine, while investigating a water supply in July, 1922. The water was taken from a spring fed lake and pumped directly into the distribution system, being treated with chlorine at the pump intake. It had been determined that maintaining a residual of 0.08 to 0.10 p.p.m. free chlorine at a sampling point about two miles from the pump station produced a water of good sanitary quality. At the time of this investigation it was found that the untreated water gave a reaction with ortho-tolidine equivalent to 0.07 p.p.m. free chlorine. The water contained 0.4 p.p.m. Fe and 0.3 p.p.m. Mn, and filtering through "Whatman No. 44" filter paper removed 0.35 p.p.m. Fe and 0.2 p.p.m. Mn. The filtrate from the raw water did not react with the ortho-tolidine, while the residue on the paper gave a positive test. On filtering the chlorinated water the filtrate gave a definite reaction, but with increased dose the reaction was not proportionate to the chlorine introduced.

It was decided that the reaction of ortho-tolidine with the raw water was caused by the iron and manganese present, and in addition to the ortho-tolidine test, regular bacteriological examinations would be necessary to control the chlorine sterilization process.

[1] Bacteriologist, Oliver Iron Mining Company, Hibbing, Minn.

During the past 3 years thirty lakes, ten of which are used as sources for public water supplies, have been examined as to the reaction with ortho-tolidine. All but five, at one time or another, gave a reaction varying from a trace to 0.2 p.p.m. free chlorine. Sixty samples when taken did not give the reaction; about half of these reacted after standing in the laboratory, and only 27 of the 150 samples examined failed to produce a color with ortho-tolidine. When filtered through "Whatman No. 44" filter paper only eight of the 100 samples thus treated gave a color. The residue on the paper washed back into the filtrate gave approximately the same color as the original with ortho-tolidine. All samples giving a positive test contained iron and manganese.

When ortho-tolidine is added, drop by drop, to a water giving a positive test, the following color changes are often observed: blue, blue-green, and finally yellow. It was thought that this may be due to iron and manganese, but the same color changes occur with chlorinated water free from these elements, and, vary with the hydrogen-ion concentration of the solution. The first indication of green is noticed at a pH of 4.8, the full blue at 6.2, while at 6.4 a faint muddy color appears, which is not affected by further changes in the pH of the solution. These color changes were found only in water containing free chlorine or manganic compounds. Water, alcohol, and sulphuric acid solutions of ortho-tolidine give the same results as the standard ten per cent hydrochloric acid reagent. All pH determinations were made colorimetrically, and were subject to the errors introduced by the action of free chlorine on the indicators.

From a series of laboratory experiments, conducted for the purpose of observing the reaction of iron and manganese salts with ortho-tolidine, the following results were noted. Dilute solutions of ferrous and manganous salts, up to 10 p.p.m., do not react with ortho-tolidine. Solutions of ferric chloride do not react immediately with ortho-tolidine; but on standing develop a marked color. A solution containing 2 p.p.m. iron as ferric chloride, to which the usual amount of reagent, 1 cc. to 100, has been added, will, at the end of twenty minutes, develop a color equivalent to 0.03 p.p.m. free chlorine: on standing 90 minutes the color developed is equivalent to 0.10 p.p.m. free chlorine. For all practical purposes, ferric salts do not interfere with the accuracy of the ortho-tolidine test.

Water containing manganese as manganic hydroxides gives the same reaction with ortho-tolidine as chlorinated water, irrespective

of whether a water, alcohol, sulphuric acid, or hydrochloric acid solution of the reagent is used. The color changes produced, yellow, green, and blue, vary with the hydrogen-ion concentration of the solution as in water containing free chlorine. The ortho-tolidine reagent is very sensitive to water containing manganic hydroxides, 0.05 and 2.0 p.p.m. giving a color equivalent to 0.03 and 0.5 p.p.m. free chlorine, respectively.

A ground water with an alkalinity of 70 p.p.m. and a pH of 6.2, containing 0.4 p.p.m. Fe and 0.7 p.p.m. Mn was tested for its reaction with ortho-tolidine on numerous occasions. The water as drawn from a tap gives no reaction; boiling and cooling the water changes the pH to 7.6 and with ortho-tolidine produces a color equivalent to 0.15 p.p.m. free chlorine. Filtering through "Whatman No. 44" filter paper removes all the iron and 0.3 p.p.m. Mn. The filtrate does not react with ortho-tolidine.

Surface waters which give a color reaction with ortho-tolidine contain iron and manganese. The filtrate from these waters do not give the color reaction. Water containing only iron compounds, when these do not exceed 10 p.p.m., do not react with ortho-tolidine. Water containing even very small amounts of manganic hydroxides give the same reaction as those produced with free chlorine.

SOCIETY AFFAIRS

INDIANA SECTION

The Indiana Section met at Purdue University on March 25 and 26, 1926.

From the time the registration started until the close of the last session, the attendance was good.

There were a number of mayors, fire chiefs, and city engineers in attendance, taking part in the discussions and evidencing a desire to co-operate toward a more effective relationship between the water utilities, the various city departments, and the public.

Dean A. W. Potter of Purdue welcomed the Association and emphasized the desire of the university to establish a close contact with the water supply industry and to be of service in every way possible.

H. S. Morse responded thanking Dean Potter for his assistance and interest in the advancement of the art.

The development of the Boonville, Indiana, water supply was made imperative by a serious water shortage which the people of the town financed in order to avert a threatened water famine. The account of the very rapid construction was given by Charles Brossman, Consulting Engineer, who designed and built the new system.

Many fire chiefs enjoyed the paper presented by Percy Bugbee of the National Fire Protection Association and entered into the discussion. The general adoption of fire prevention ordinances controlling roofing materials, electrical installations, and general clean up was urged.

Mr. Zucrow, research assistant in the Purdue Hydraulics Laboratory, outlined the various methods of measuring liquids and demonstrated them under working conditions in the laboratory.

Beekman C. Little attended the dinner and spoke a few minutes. On account of illness, he was unable to attend all the sessions.

Following the dinner, a group of Purdue students entertained the Association with novel music and athletic events of a very high order.

Frank C. Jordan, past President of the Association, presided at the evening meeting, the program of which was broadcasted.

Dr. A. J. McLaughlin, Senior Surgeon of the United States Public

Health Service traced the development of public health measures from early times. Centuries before the development of the germ theory of disease, the danger of foul water was recognized and extensive works for the distribution of water and the collection of sewage were in use. The prosperity and development of the present day is possible in a large measure by virtue of the great advances made in disease control.

Fire Prevention in Indiana was the subject of an address by Clarence Goldsmith, Assistant Chief Engineer of the National Board of Fire Underwriters. Mr. Goldsmith asked for proper regulatory laws, but stressed the need for adequate and continuous inspection and the development in the public mind of a desire to avoid hazardous construction and the maintenance of bad conditions.

On Friday morning, Professor W. K. Hatt of Purdue traced the development of the concrete industry and detailed some of the new work which has made possible the accurate control of strength in the finished structure. He suggested that a contractor be permitted to use such mixes as he chooses to produce the strength required. If a wet mortar costs less to handle than the additional cement required, he should be permitted to use it provided the proper cement water ratio is maintained. This paper was discussed by J. W. Kelly of the Portland Cement Association and W. C. Mabee of the Indianapolis Water Company.

L. S. Finch, Director of the Water and Sewage Division of the Indiana State Board of Health, and H. A. Dill, Manager of the Richmond Water Company, reported some of the more serious water shortages in the state and insisted that many could be avoided by intelligent study of the distribution of the demand and the available supply using data developed over a period of years.

The Electrification of the Lafayette Water Works has resulted in a very substantial saving in operating costs. This work was reported by John W. Moore, Consulting Engineer, Indianapolis, who designed it.

W. C. Purdy of the United States Public Health Service was unable to be present, but his most enjoyable paper was read and discussed at length. An increasing interest is being shown in the evidence obtainable by a study of the plankton in our streams, and the pleasure and fascination of such a study are being realized.

The power end of the water works plant was very ably handled by Professor A. W. Cole of Purdue. Professor Cole called attention

to the very general disregard of the boiler equipment and emphasized the necessity for not only proper attention to operation and repair, but for modern efficient installations, saying that many times an old out-of-date boiler cost much more in operation than the interest on a new plant.

Every water works man is concerned in pipe laying and John W. Toyne, Consulting Engineer, South Bend, found an attentive audience for his discussion of Pipe Laying Methods. Mr. Toyne referred to the tendency to eliminate hand labor by the use of ditchers and back fillers. He ridiculed the idea of using new pipe lines prior to sterilization after exercising such care in the preparation of the water for consumption.

Every water supply organization hopes to avoid offering cause for complaint on the part of a customer. G. C. Staley of the Indianapolis Water Company outlined some of the means used to avoid mistakes and unfavorable impressions on the public. Common courtesy intelligently and consistently applied avoids many unpleasant situations.

E. A. Scott, Director of Public Relations, Interstate Public Service Commission, outlined the general modern policy governing the relation between utilities and the public, looking to a friendliness displacing the antagonistic attitude formerly often assumed by both.

This was one of the most successful meetings the Indiana Section has ever held. The attendance was large throughout the meeting. The papers were well prepared and on topics of wide interest. The facilities offered at Purdue University for such a gathering are splendid and our contact with the faculty most pleasant.

The following officers were elected to serve for one year.

President, H. S. Morse.

Vice-President, John W. Moore.

Secretary-Treasurer, C. K. Calvert.

Assistant Secretary, Lewis S. Finch.

Executive Committee: F. C. Jordan, W. L. Younce, W. C. Ridgeway, Howard Dill, W. H. Durbin, Charles Brossman, and I. L. Miller.

REPORT OF THE RESOLUTIONS COMMITTEE

(1) This Association wishes to express its appreciation for the courtesies that it has received from the Staff of Purdue University. We could not ask for more. Especially do we appreciate the way in which Professor W. A. Knapp has handled the local arrangements for this meeting. Preparation for

our meetings has never been better made. Our renewed acquaintance with the University strengthens our loyal support of it. The training that it gives to the students is of value to all public utilities as well as to the people at large.

We appreciate the cordial invitation to return for later meetings and recommend that this Association meet at Purdue University whenever possible.

(2) We are glad to have had the privilege of discussing fire prevention measures during this meeting. No more important topic can be discussed by our organization. To those actively in this work we renew our support. Indiana can well carry on the systematic community work in reducing fire losses. We pledge our full support to a constructive program of active fire prevention in Indiana.

(3) We view with pride the growth of the American Water Works Association. We believe that every wide awake man in public water supply work should be a member. He will find himself able to do better work by so doing. We especially urge the Mayors of Indiana to see that their water departments are represented in the membership of the Association.

(4) We wish to restate the object of this Association to be "the study of the sources of water supply in the State of Indiana, their conservation and purification."

It is our desire to insure to every citizen a safe, wholesome and adequate water supply, and to that end we ask the intelligent cooperation of the people of Indiana.

(5) We remember with thankful hearts the years of service given by Dr. John N. Hurty.

We believe that his successor, Dr. Wm. F. King, is carrying on the work in a way that is for the best interests of the state.

We heartily commend the action of the Indiana State Board of Health in regard to the pollution of the lakes of the state, and it is the desire of this Association that this action be extended to include all of the water courses of Indiana.

(6) A number of years have elapsed since the American Water Works Association has met in Chicago.

In 1927 several large projects are expected to be completed. It is felt that the National Association may be of assistance in hastening the construction of certain additional works to the improvement of the Chicago Water Supply.

We, therefore, direct the secretary to petition the Executive Board of the American Water Works Association to act favorably on the invitation from Chicago to hold the 46th Annual Convention in that city.

CENTRAL STATES SECTION

The Central States Section met in Erie, Pa. on October 9 and 10, 1925.

The Erie Convention was entertained by the Commissioners of Water Works in the City of Erie and others.

The Commissioners opened headquarters in the Lawrence Hotel and were at home to all of the delegates day and night, during the

two day period. There was an attendance of about 100 delegates, and meetings were well attended and the papers, with discussions, were good.

After the scheduled meetings on the first day the delegates were taken by automobile for a trip around the City, including an inspection of the manufacturing plant of the Hays Manufacturing Company, returning to the hotel where dinner was provided for all by the attending members of the Manufacturers Association. After the dinner the delegates were guests of the Hays Manufacturing Company at a theater party and this was followed by a reception at the home of Mr. Gensheimer, Secretary to the Water Commissioners.

At the end of the afternoon session on Saturday the delegates were again taken for an automobile trip over the new Seneca Highway of Presque Isle peninsula leading to Water Works Park. On returning from this trip the delegates were the guests of the Water Commissioners at a dinner served at one long table on the operating floor of the filtration plant.

At the end of the Saturday afternoon session the election of officers resulted as follows:

President, J. W. Ellms;

Vice-President, Chester F. Drake;

Trustees, Mentor Hetzer, D. C. Grobbel.

The Secretary-Treasurer is to be appointed by the newly elected officers.

The 1926 Convention is to be held at Cleveland at a date to be fixed by the incoming officers. The incoming officers were also authorized by the 1925 Convention to prepare rules and regulations for the activities of the Section.

The program follows:

FRIDAY, OCTOBER 9

Morning Session

9:00 a.m. Address by President Gensheimer.
Welcome by Mayor of the City of Erie.
Minutes of Last Meeting.

10:00 a.m. Address by the President of the American Water Works Association. H. F. Huy.

10:40 a.m. Address by the Secretary of the American Water Works Association. Beekman C. Little.

11:20 a.m. Installation of Meters in the City of Erie. D. W. Harper.

Afternoon Session

2:00 p.m. Water Supply and Sewage Disposal of Cities on the Great Lakes. J. W. Ellms.
3:00 p.m. Zeolite Softening Plant of the Ohio Valley Water Company. F. B. Beech.
3:30 p.m. Another Type of Dry Feed Machine. W. U. Gallagher.
4:00 p.m. Progress of Melcroft Coal Case. C. A. Emerson.

SATURDAY, OCTOBER 10

Morning Session

9:00 a.m. Office Administration of City Water Departments. D. C. Grobbel.
10:00 a.m. Council on Standardization led by J. N. Chester followed by Discussion of the new Manual of Water Works Practice.

Afternoon Session

2:00 p.m. Meter Maintenance Under Conditions of Hard Water. George Whysall.
2:40 p.m. Superintendents' Session.
4:00 p.m. Question Box.
Election of Officers and 1926 Convention City.

ILLINOIS SECTION

The eighteenth annual meeting of the Illinois Section of the American Water Works Association was held at the University of Illinois on March 24 and 25, 1926. This was one of the most successful meetings in recent years and the attendance of members of the Illinois Section was greater than for many years past. (An approximate check shows about same for 1916 and 1917.) The attendance included thirty-nine active members, representatives of three corporate members, and representatives of seven associate members of this section. The attendance of members from outside of the state was comparatively small. It included two active members and representatives of six associate members of the society. Several were prevented from attending by illness, previous engagements, and attendance at the Indiana section meeting.

Every paper listed on the program was presented and they were freely discussed. The talk by Beekman C. Little, Secretary of the Association, was on affairs of the Association and was very interesting and instructive.

The weather was exceptional and many availed themselves of the opportunity to see the experimental and demonstration apparatus

which had been explained at the meeting by Professors M. L. Enger and H. E. Babbitt; to accept the courtesy of Mr. Amsbary and visit the plant of the Champaign and Urbana Water Company; and to accept the courtesy of G. H. Radebaugh, manager of the Urbana-Champaign Sanitary District, and visit the sewage disposal plant of the district.

The following resolution was adopted:

Whereas the Illinois section of the American Water Works Association has suffered a loss in the death of G. A. Wadsworth, Superintendent of Water Works at Evanston, a valued member of this organization, who was killed by accident on October 1, 1925, while actively engaged in performing his official duties:

Therefore be it resolved that this society express its deep regret at the loss of this member and extend its profound sympathy to his family and further be it resolved that this resolution be spread on the minutes, and that copies be sent to the Mayor of Evanston, the members of his family, and the editor of the Association for publication in the Journal.

A resolution urging the executive committee to hold the 1927 annual meeting in Chicago was adopted unanimously. It follows:

Whereas, The City of Chicago through its Mayor, Commissioner of Public Works, and the Association of Commerce, has extended an invitation to the American Water Works Association to hold its 1927 convention in Chicago, and

Whereas, the Chicago water works, through the construction of the world's largest pumping station, which will be completed about the time of the 1927 convention, its tunnel construction, installation of meters at a rate of 40,000 meters per year, and other construction projects of both large and small magnitude, offer much of interest and educational advantages to the members of the A. W. W. A., and

Whereas, the passage by the City Council of Chicago in September of last year of a universal metering ordinance paves the way for the practical financing of needed filtration plants in that city, and

Whereas, the A. W. W. A. by meeting in Chicago in 1927 is offered the opportunity of being of very great service to the profession and the city officials by giving stimulus in focusing public attention to the water purification projects which have been proposed, and

Whereas, the City of Chicago has not entertained the A. W. W. A. since 1902, and is now desirous of doing so, and

Whereas, the hotel and convention facilities of Chicago are unequaled, and Chicago's train schedules place it easy of access from all sections of the country.

Now Therefore Be it Resolved by the Illinois Section of the A. W. W. A. that the Convention Committee of the A. W. W. A. and the district representative on the Executive Board be respectfully advised that it is the desire of the Illinois Section that the 1927 convention be held in Chicago.

The following officers were elected for the coming year: Chairman W. R. Gelston; Vice Chairman, G. C. Habermeyer; Treasurer, H. E. Keeler; Trustee, L. R. Howson.

The program follows:

WEDNESDAY, MARCH 24, 1926

9:30 a.m.

Report of Secretary. G. C. Habermeyer.
Report of Treasurer. H. E. Keeler.
Promotion of Municipal Bond Issues. W. R. Gelston.
Water Certificates to Finance Water Supply Plants in Illinois. Paul E. Green.
Operation of Electrically Driven Pumping Stations with Respect to Peak Loads of Power Company. J. A. Rue.
Semipublic Water Supplies and Approved Types of Wells in Illinois. Carl D. Gross and H. F. Ferguson.
Automatic Primers. F. H. Bradford.

1:30 p.m.

Rehabilitation Program for the Racine, Wis. Water Works. D. H. Maxwell.
The Quincy Reservoir. P. Hansen, R. S. Rankin, J. K. Giesey.
Small Town Water Works. Harold F. Hunter.
Tests of Strength Properties of Cast Iron Pipe. A. N. Talbot.
Experimental and Demonstration Apparatus at the University of Illinois
Friction in Water Pipe: Air Lift Pump: Discharge from Filter Manifolds. M. L. Enger.
Plumbing. H. E. Babbitt.
Trip through the laboratory and demonstration of apparatus.

6:30 p.m.

Annual Dinner, Urbana-Lincoln Hotel

Address of Welcome. M. S. Ketchum.
Response by Chairman. L. R. Howson.
Election of Officers.
Short talks by Beekman C. Little, Secretary of the American Water Works Association, and others.
The Water Works from the Architect's Viewpoint. V. A. Matteson.
A Trip Through Yellowstone (Courtesy of the Northern Pacific Railroad).

THURSDAY, MARCH 25, 1926

9:30 a.m.

Shallow Well Development. John Oliphant.
The Water Supply of the Chicago and Northwestern Railway. R. E. Coughlan.

The Water Supply of the Illinois Central Railroad. C. R. Knowles.
Duties of the Railway Water Service Inspector. J. P. Hanley.
Experiences in the Water Works Game. George W. Hanley.
Responsibility of Municipalities, Water Companies and Individuals for Water Borne Illness. Dr. I. D. Rawlings, and H. F. Ferguson.
Experiences with Cross Connections in Chicago. Arthur E. Gorman.

1:30 p.m.

The Quality of Lake Michigan Water and Water Supplies from Waukegan, Ill., to Gary, Ind. F. W. Mohlman.
Comparative Studies of Standard Methods and the Brilliant Green Bile Medium on Lake Michigan Water at Chicago. C. C. Ruchhoft.
Differential Tests for the Coli-Aerogenes Group of Bacteria. S. A. Koser.
Operation of the Hinsdale Water Softening Plant. Frank G. Danielson.
A Survey of Stream Pollution in Illinois. A. M. Buswell.
Stream Pollution and Sewage Purification. W. D. Hatfield.
Trips of plants of Champaign & Urbana Water Company and Urbana-Champaign Sanitary District.

ROCKY MOUNTAIN SECTION

Conference of Water Superintendents from Wyoming, Colorado and New Mexico

The Conference opened at 9:00 a.m. February 23, 1926, at Denver and proceeded according to the program.

During the second session, temporary officers were elected as follows: Chairman, P. E. Strouse, Water Supt., Rocky Ford, Colo., and Secretary, W. S. Rathbun, Engineer, Mt. States Inspection Bureau. These approinted a committee to investigate and report upon the formation of a permanent water works organization for this territory.

The report of the committee, presented at the morning session of the second day, recommended the formation of a Rocky Mountain Section of the American Water Works Association. This met with the unanimous approval of those in attendance. Permanent officers were then elected, and instructed to proceed with the formation of the Section, to include Wyoming, Colorado and New Mexico, and possibly later Idaho, Utah, Arizona and western Nebraska. The officers for the Section are: Chairman, P. E. Strouse, Water Supt., Rocky Ford, Colo.; Vice Chairman, A. W. Stedman, Water Supt., Canon City, Colo.; Secretary-Treasurer, D. E. Kepner, Sanitary Engineer, Colo. State Board of Health. The directors are: E. C. Gwillim, Water Supt., Sheridan, Wyo.; D. Z. Bell, Water Supt.,

U. P. R. R., Rock Springs, Wyo.; D. P. Porter, Water Supt., Pueblo, (North Side) Colo.; W. S. Rathbun, Engineer, Mt. States Inspection Bureau, Denver, Colo.; Paul S. Fox, Sanitary Engineer, New Mexico Bureau of Public Health, Santa Fe, N. Mex.; and Cicero Oggle, Water Supt., East Las Vegas, N. Mex.

The dinner at the evening session of the first day, held at the Albany Hotel, was given through the courtesy of six water works supply houses, including:

Colorado Fuel & Iron Company
Crane-O'Fallon Company
Hendrie & Bolthoff Mfg. & Supply Company
Neptune Meter Company
National Tube Company
Wallace & Tiernan Co., Inc.

Transportation to the new Marston Lake Filter Plant of Denver was provided by the Board of Water Commissioners, and the party was escorted by Mayor Stapleton, and R. S. Sumner, Burton Lowther and O. J. Ripple, General Manager, Chief Engineer and Filter Superintendent respectively, of the water works. This was an exceedingly interesting trip, as the new plant is modern and somewhat unique, employing anthracite coal as a filtering medium and being equipped for "air wash."

A total of 100 men, water superintendents local health officers and water works engineers from the three states, registered for the Conference. They were very generous in their praise of the meetings, and, to all appearances, the Conference was a success.

The program follows:

TUESDAY, FEBRUARY 23

Morning Session, 9:00 a.m.

Address of Welcome. Dr. S. R. McKelvey, Secy., Colo. State Board of Health.

Early Examination of Water Supply in Colorado. Dr. Wm. C. Mitchell, Bacteriologist, Colorado State Board of Health.

A Bacteriological Study of the Las Animas River. Paul S. Fox, Sanitary Engineer, New Mexico Bureau of Public Health.

Microscopic Organisms Causing Tastes and Odors in Water. George Turre, Chemist, Denver Municipal Water Company.

Chlorination of Water. J. A. Strang, Wallace & Tiernan Co., Newark, N. J.

Afternoon Session, 2:00 p.m.

Watershed Sanitation. Dr. Sherman Williams, Member Colo. State Bd. of Health.

Financing Water Works Projects. C. N. Phillips, Jas. H. Causey Co., Investment Bankers, Denver.

Fire Protection. W. S. Rathbun, Engineer, Mt. States Inspection Bureau.

Description of Rocky Ford Filtration Plant. P. E. Strouse, Water Supt., Rocky Ford, Colorado.

Design and Maintenance of Distribution Systems. D. D. Gross, Office Engineer, Denver Municipal Water Company.

Dinner Session, 6:30 p.m.

State Health Department Service on Water Supplies:

Wyoming. Dr. G. M. Anderson, Wyoming State Health Officer.

New Mexico. Paul S. Fox, New Mexico State Sanitary Engineer.

Colorado. Dana E. Kepner, Colorado State Sanitary Engineer.

Motion Pictures. The Manufacture of Pipe. Courtesy National Tube Co.

Iodin and Goitre. Dr. Omer R. Gillett, Health Officer, Colo. Springs.

U. S. Public Health Service and Municipal Water Supplies. I. W. Mendelsohn, Associate Sanitary Engineer, U. S. P. H. S.

WEDNESDAY, FEBRUARY 24

Morning Session, 9:00 a.m.

Discussion of Bookkeeping Systems for Municipal Water Companies. Led by P. E. Strouse, Water Supt., Rocky Ford, Colo.

Discussion of Formation of a Section of the American Water Works Association. Led by W. S. Rathbun, Engineer, Mt. States Inspection Bureau.

Round Table Discussions, Miscellaneous.

Afternoon Session, 1:30 p.m.

Trip to New Marston Lake Filter Plant. (Courtesy of Denver Municipal Water Company).

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

An Aspect of the Hydraulic Jump Problem. A. P. Flockart. Eng. News-Rec., **95**: 728, October 29, 1925. Brief illustrated discussion.—*R. E. Thompson.*

Pipe Pusher Eliminates Necessity of Digging Shallow Trenches. Eng. News Rec., **95**: 735, October 29, 1925. One-man pipe pushing machine manufactured by Grant Mfg. Co., Council Bluffs, Ia., described and illustrated. Claimed that all possibility of bending is eliminated. Speed capacity is approximately 3 lengths of pipe per hour.—*R. E. Thompson.*

Grouting Reinforces Rock at Oak Grove Surge Chamber. Eng. News-Rec., **95**: 746–9, November 5, 1925. When water was admitted to surge tank of Oak Grove hydro-electric plant of Portland Electric Power Co., on Clackamas River, Ore., concrete lining cracked, resulting in considerable leakage. Grouting was selected in preference to steel lining as method of repair and after two successive grout treatments, which are described in some detail, leakage was reduced from 2–3 to 0.42 second feet.—*R. E. Thompson.*

A Manual for Building and Operating Sliding Forms. R. F. Egelhoff. Eng. News-Rec., **95**: 786–92, November 12, 1925. Detailed illustrated discussion of employment of sliding forms in concrete construction.—*R. E. Thompson.*

Convenient Scheme for Ordering Pipes and Fittings. Eng. News-Rec., **95**: 809, November 12, 1925. Scheme described for laying out and listing pipe details in water circulating systems, etc., developed by Southern Pacific R.R. —*R. E. Thompson.*

Equipment Measures Concrete Aggregates by Weight. Eng. News-Rec., **95**: 819, November 12, 1925. Brief illustrated description of equipment manufactured by Blaw-Knox Co., Pittsburgh.—*R. E. Thompson.*

Cement Lining in Wrought Iron and Steel Pipe. Eng. News-Rec., **95**: 653, October 15, 1925. Cement-lined pipe, $\frac{3}{4}$ to 4 inches in diameter, manufactured by Cement Lined Pipe Co., Lynn, Mass., described briefly, and standard lead-

lined fitting, by means of which protective lining is made continuous at joints, illustrated. Both lead and cement linings are guaranteed against injury during shipping and handling.—*R. E. Thompson.*

Why Water Mains Burst. H. F. Dunham. Eng. News-Rec., **95**: 646, October 15, 1925. Dunham claims existence of errors in factors of safety adopted by American Water Works Association for cast iron pipe.—*R. E. Thompson.*

Small Vacuum Pump for Priming Centrifugal Pumps. Eng. News-Rec., **95**: 652, October 15, 1925. Brief illustrated description of dry-type vacuum pump manufactured by Barrett, Haentjens & Co., Hazleton, Pa., for priming centrifugal pumps.—*R. E. Thompson.*

Steel Multiple Stops Swirling in Surge Chamber. Eng. News-Rec., **95**: 709, October 29, 1925. When additional unit was recently added to three already in service at White River plant of Puget Sound Light & Power Co., Seattle, Wash., it was found that new combination of hydraulic conditions, not contemplated in original design, caused violent swirling in surge chamber. Steel manifold in bottom of surge chamber which effectively eliminated difficulty without interfering with service demands, described briefly and illustrated.—*R. E. Thompson.*

Large Multiple-Arch Dam Being Built in Italy. J. B. Lippincott. Eng. News-Rec., **95**: 710–1, October 29, 1925. Illustrated description of unusual multiple-arch dam with maximum height of 170.6 feet and length of 722 feet, known as Tidone Barrage, now under construction on Tidone River in northern Italy. Cement plant with vertical kilns was constructed especially for the work.—*R. E. Thompson.*

Imperial Valley Drainage Problems—Progress in Solution. D. W. Murphy. Eng. News-Rec., **95**: 804–7, November 12, 1925. Illustrated description of works for control of ground water in Imperial Valley (California and Mexico). —*R. E. Thompson.*

Electric Pumping at Water Stations. Eng. News-Rec., **95**: 807–8, November 12, 1925. Brief data given on use of electric power for pumping in railroad water stations. Under favorable conditions electrically operated stations are cheaper to install and maintain than steam plants. Although fuel-oil engines are considered cheapest source of power, this is sometimes offset by decreased cost of attendance for electrical stations. Motor drive is employed with every type of pump, but it is particularly adapted to direct-connected centrifugal pumping units.—*R. E. Thompson.*

Medium Pressure Valves Have New Features. Eng. News-Rec., **95**: 819, November 12, 1925. Brief illustrated description of new medium pressure bronze valves with removable disks manufactured by Jenkins Bros., N. Y.—*R. E. Thompson.*

Water Power Investigations by the Geological Survey. B. E. Jones. Eng. News-Rec., 95: 830–1, November 19, 1925. Outline of activities of United States Geological Survey in collecting data on river flow, geological conditions, etc. To date 16,000 miles of river courses have been surveyed. Gaging stations now being maintained number 1,673.—*R. E. Thompson.*

Pompeiians Laid Water Mains on Both Sides of Street. M. M. O'Shaughnessy. Eng. News-Rec., 95: 850, November 19, 1925. Attention drawn to fact that in Pompeii, 2000 years ago, 2 to 3-inch lead water mains were laid in the narrow sidewalks.—*R. E. Thompson.*

New Work on Specifications for Materials. Eng. News-Rec., 95: 869, November 26, 1925. Brief data on work carried out or in progress with regard to specifications of American Society for Testing Materials given. Experiments on corrosion of copper-bearing and non-copper-bearing steels indicate that resistance to corrosion is decidedly greater when copper is present.—*R. E. Thompson.*

Leakage Tests of Cast Iron Force Main at Columbus, Ohio. John C. Prior. Eng. News-Rec., 95: 870–2, November 26, 1925. Data given on leakage test of new 36- and 42-inch cast iron main. Maximum leakage allowed by contract was 528 gallons per 24 hours per inch-mile of pipe, and average leakage (corrected to standard pressure of 110 pounds) during 6-day test was only 87.3 gallons. Concluded that one-half maximum allowable leakage could be obtained with little difficulty and that leakage as low as 100 gallons per inch-mile per 24 hours could be obtained under conditions and pressures obtaining on this line. Total cost of 3 miles of new main was just under $500,000. Pipe and fittings were purchased and delivered along pipeline for approximately $270,000.—*R. E. Thompson.*

Fabricating Strength of High-Strength Steel. Eng. News-Rec., 95: 878, November 26, 1925. Brief data given derived from studies carried out in connection with extending use of high-strength structural steel in Germany. General conclusion drawn is that as compared with ordinary soft structural steel (54,000 to 64,000 pounds ultimate) extra shop cost of high-strength (68,000 to 82,500 ultimate) is 15 to 20 per cent.—*R. E. Thompson.*

Welded Headers Too Rigid for Meter Banks. Eng. News-Rec., 95: 881, November 26, 1925. Brief illustrated description of connection developed by Spring Valley Water Co., San Francisco, for banks of 2-inch meters, which are employed in preference to single meters of large size.—*R. E. Thompson.*

Arch Dam Repaired by Fills Above and Below Structure. John E. Field. Eng. News-Rec., 95: 953–4, December 10, 1925. In investigation of concrete arch dam 50 feet in height and 300 feet in span for city of Manitou, Colo., two outstanding faults in construction were obvious—use of disintegrated granite as sand, and poor workmanship in mixing and placing. Considerable disintegration had taken place as result of seepage and by freezing of saturated

concrete, and there was a heavy deposit—½ inch in thickness in places—of calcareous material on lower face of dam. Repairs carried out consisted of partial earth fill on upper side and backing on lower side to full height of dam. Construction joints in concrete were also raked out and filled with 1:2 mixture of cement and clean sound quartz sand.—*R. E. Thompson.*

Water Meters Accurate After Long Service. Eng. News-Rec., 95: 881, November 26, 1925. During conversion of meters on residence services in San José, Calif., large number of meters which had been in use for periods ranging up to 15 to 20 years were tested. Of 955 meters tested in 1 month, average service of which was probably 7 to 8 years, only 3 were found to run fast.—*R. E. Thompson.*

Small Flexible Ditcher For Use in Public Service Field. Eng. News-Rec., 95: 895, November 26, 1925. Brief illustrated description of machine manufactured by Parsons Co., Newton, Ia., which digs 12 to 24 inches wide, changing width by inches, and to maximum depth of 7 feet.—*R. E. Thompson.*

Lining Procedure in Holland Vehicular Tunnel. Eng. News-Rec., 95: 902–7, December 3, 1925. Illustrated description of procedure employed in lining tunnel under Hudson River first with concrete and then with glazed tile.—*R. E. Thompson.*

Motor Unit Completely Closes Valve Before Motor Stops. Eng. News-Rec., 95: 931, December 3, 1925. Brief illustrated description of electrically driven valve operating mechanism, manufactured by Coffin Valve Co., Neponset, Mass., which completely closes valve before motor stops, thus eliminating making of final tightening by hand.—*R. E. Thompson.*

High Wastage of Water at Sacramento, Calif. Eng. News-Rec., 95: 957, December 10, 1925. Provision in city charter at Sacramento prohibits installation of meters on water services to residences, and as result, consumption and water waste are very high. System serves 85,000 water users, and minimum night flow is at rate of 12 m.g.d., and average night rate of flow is 15 m.g.d. During 1924 daily average consumption was 22 m.g.d. and per capita consumption, 270 gallons per day. For short periods consumption rate ranges up to 600 gallons per capita per day. In house-to-house inspection recently undertaken 98 per cent of premises visited had leaky fixtures. Inspection and corrective measures under way are expected to decrease waste 15 to 20 per cent. —*R. E. Thompson.*

Flood Protection Works Progress at Peru, Ind. Eng. News-Rec., 95: 962–3, December 10, 1925. Illustrated description of Peru flood protection works, undertaken as result of loss sustained in great Ohio Valley floods. City is situated mainly on low ground along both sides of Wabash River.—*R. E. Thompson.*

Belt Conveyor Handles Concrete to Slopes of Drainage Canal. Eng. News-Rec., 95: 964–5, December 10, 1925. Brief illustrated description of concreting plant employed on River des Peres drainage works in St. Louis.—*R. E. Thompson.*

Large Channel-Dredging Project at Portland, Ore. Eng. News-Rec., 95: 982–4, December 17, 1925. Illustrated description of channel improvement work on 12-mile stretch of Willamette River between Portland and Columbia River.—*R. E. Thompson.*

Large Pipe in Trench Moved Bodily by Motor Trucks. Eng. News-Rec., 95: 966, December 10, 1925. Brief illustrated description of method employed in Sacramento in moving 720-foot length of 36-inch water pipe to parallel position some 9½ feet distant. Trench sufficiently wide to allow pipe to be rolled to new location was excavated and pipe was moved bodily by 5 motor trucks. When pipe was reconnected no leaks were found. Cost of work was $2.784 per foot.—*R. E. Thompson.*

Dam Built on Miter Lock Gate Principle. E. W. Lane. Eng. News-Rec., 95: 967, December 10, 1925. Small mill dam near Ithaca, N. Y., 35 feet wide at top and sustaining head of about 12 feet, constructed of timber on miter lock gate principle, described and illustrated.—*R. E. Thompson.*

Does Silting Affect Cutting Power of Streams? Eng. News-Rec., 95: 968–9, December 10, 1925. Discussion of article of L. M. Lawson by Herman Stabler, and reply by author.—*R. E. Thompson.*

Colorado River Problems. Eng. News-Rec., 96: 56–7, January 14, 1926. Conditions re river control and allotments of water for power, irrigation, etc., discussed.—*R. E. Thompson.*

Pueblo Flood Protection. Eng. News-Rec., 96: 84, January 14, 1926. Work of Pueblo Conservancy District outlined.—*R. E. Thompson.*

Hetch Hetchy Project. Eng. News-Rec., 96: 84, January 14, 1926. Status of project outlined. Expenditure to date, exclusive of interest, totals $44,000,000.—*R. E. Thompson.*

Building 29-Foot Concrete Arch Sewer at Richmond, Va. Eng. News-Rec., 95: 996–7, December 17, 1925. Shockoe Creek sewer construction described and illustrated.—*R. E. Thompson.*

Baton Rouge, La. Eng. News-Rec., 95: 998–9, December 17, 1925. Water derived from artesian wells 1300 to 2200 feet deep, is supplied by private company. Electrical pumping units have been recently installed to meet peak demand.—*R. E. Thompson.*

Countersunk Rivets as Strong as Buttonhead in Tests. Eng. News-Rec., **95**: 1023, December 24, 1925. Tests of 168 riveted joints reported by J. B. Kommers in Bull. of University of Wisconsin, Vol. 9, No. 5, indicate that countersunk rivets are as strong in shearing and bearing resistance as button-head rivets.—*R. E. Thompson.*

Silt and Channel Conditions in Colorado River Delta. S. L. Rothery. Eng. News-Rec., **95**: 1068–71, December 31, 1925. Data on conditions in Colorado River Delta.—*R. E. Thompson.*

Montgomery, Ala. Eng. News-Rec., **95**: 1075–6, December 31, 1925. Water supply system is in charge of a commission but city engineer has practical control of all properties. Heretofore extensions to system were financed by bond issues, etc., but recently practice has been adopted of not installing mains and hydrants until estimated expenditure has been collected from property owners.—*R. E. Thompson.*

Impulse Wheel Shows Efficiency of 93 Per Cent. Eng. News-Rec., **95**: 858, November 19, 1925. In recently conducted test on Pelton water wheels in Pit River No. 3 plant of Pacific Gas and Electric Co., in northern California, efficiency of 93 per cent was certified to by representatives of power company, manufacturers, and independent engineer. Unit has nominal rating of 29,000 h.p., and was under normal head of 280 feet during test.—*R. E. Thompson.*

Blowpipe Saves 12-Mile Water Supply Line for Road Contractor. Cont. Rec., **39**: 987, October 7, 1925. Repair by oxywelding of 12-mile 3-inch steel pipe which had been badly ruptured by freezing described briefly. Length of splits in pipe varied from 3 to 50 inches.—*R. E. Thompson.*

Construction Procedure and Methods on the Alouette-Stave Tunnel. Cont. Rec., **39**: 1054–7, November 4, 1925. Illustrated description of construction of water tunnel 3485 feet long and of arched section 178.5 square feet in area, to convey water to power house of Br. Columbia Electric Railway Co., located at Stave Lake.—*R. E. Thompson.*

Some Further Interesting Views of Stave Lake Power Plant. Cont. Rec., **39**: 1096–8, November 18, 1925. Description of further phase of Stave Falls power development, capacity of which is 87,500 h.p.—*R. E. Thompson.*

Alouette Dam Nearing Completion. Cont. Rec., **39**: 1112, November 18, 1925. Brief data on construction of concrete Alouette Dam, 1000 feet in length, which will raise water level of Alouette Lake 45 feet.—*R. E. Thompson.*

Norman Dam Power Development. S. T. McCavour. Cont. Rec., **39**: 1158–60, December 9, 1925. Description of dam and power development on western outlet of Lake of the Woods.—*R. E. Thompson.*

Failure of Dam in Wales Due to Washout Under Foundation. Eng. News-Rec., 96: 12–3, January 7, 1926. Illustrated description of failure of old concrete dam on Lake Eigiau on November 2, 1925, as result of washout due to inadequate foundation footings and poor concrete. Water discharged caused complete failure of earth-fill dam with concrete core wall on Lake Coedty. First and second mentioned dams are 1200 and 900 feet respectively above town of Dolgarrog and rush of water down steep hillside resulted in 16 deaths and considerable property damage.—*R. E. Thompson.*

Efficiency Test on High-Head Reaction Turbine. Eng. News-Rec., 96: 18–19, January 7, 1926. Tests recently made on Unit 1 of Oak Grove plant of Portland Electric Power Co. described and results tabulated and shown graphically. Turbine is vertical reaction wheel rated at 35,000 b.h.p., designed for effective head of 849 feet with prescribed generation speed of 514 r.p.m. Tests indicated efficiency of 90 per cent notwithstanding fact that effective head was 882 feet.—*R. E. Thompson.*

Water System for Humberstone, Ont. Cont. Rec., 39: 1138–40, December 2, 1925. Recently completed water distribution system described and illustrated. Filtered and chlorinated Welland Canal water will be purchased from Port Colborne.—*R. E. Thompson.*

Practical Hints on Installation and Care of Valves. Eng. News-Rec., 95: 1050, December 24, 1925. Practical suggestions re valves, derived from catalog of Kennedy Valve Mfg. Co., Elmira, N. Y., reproduced, included in which are following: (1) Avoid wrench strain. (2) Don't cut pipe threads too long. (3) Eliminate dirt. (4) Put pipe compound or cement on pipe thread—not on valve thread. (5) Keep valve tightly closed while connecting to pipe. (6) Blow out valve thoroughly before putting into service. (7) Provide ample support for maintaining alignment. (8) Don't apply wrench to hand wheel. (9) Open valve gradually. (10) Inspect regularly—operate between limits at least once per month. (11) Protect from frost.—*R. E. Thompson.*

Afforestation of Catchment Areas. J. R. Davidson. Water and Water Eng., 27: 493–497, 1925. The forested watershed is at a distinct advantage over those freed from trees. Among the advantages are more regular yield, and less erosion. Although opinions on the matter differ, it seems that more water is yielded by forested area since loss due to transpiration is less than evaporation losses of the bare watershed. State aid in forestation is available to water authorities in Great Britain either as grants, as profit-sharing agreements with the state, or as direct lease by the state. Review is given of work accomplished by Birmingham, Glasgow, Liverpool, and Manchester.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

New Water Works Plant for the City of Tallin (Reval), Esthonia. Anon. Water and Water Eng., 27: 437–8, 1925. A rapid sand filter installation of 5.5 million Imp. gallons capacity using air agitation of sand bed, and designed to operate at the rate of 1.5 gallons per square foot per minute. Guarantees are

very severe. When heated to 120°F., water shall have no taste of mud, earth, fishy material, nor of Cl. Organic matter of filtered water expressed as albuminoid NH_3 shall not exceed 0.5 p.p.m. Filtered water must be neutral to litmus at 175°F. and must not contain more than 20 bacteria per cubic centimeter when raw water contains 3000 per cubic centimeter. Bact. coli must be absent from 100 cc.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Iodoform Taste of Chlorinated Water. B. Adams. Medical Officer, Water and Water Eng., 27: 435–6, 1925. A decided taste which could not be distinguished from that of chlorophenols was given by 1 part per 1000 million of iodoform. Mere trace of alcohol or acetone with I in alkaline water will give iodoform reaction. By adding 0.2 p.p.m. I to water containing 1 p.p.m. alcohol or acetone vile tastes of iodoform were produced. Natural waters may have the necessary organic compounds set free from organic matter by bacterial action, and the I might be set free from its compounds by Cl. Chlorophenol tastes are developed instantly, but some time is necessary for the iodoform-like tastes to appear. Superchlorination and $KMnO_4$ will prevent iodoform tastes, but SO_2 does not remove them. Iodoform taste can be produced in water containing 0.005 p.p.m. I.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Recent Studies on the Purification of Water and the Action of Various Waters on Lead and Copper Pipes. John C. Thresh and John F. Beale. Water and Water Eng., 27: 475–478, 1925. Experiments for Chelmsford Corporation at Langford with excess lime method of water purification have been successful and it is planned to erect full size plants. Water will be derived from two small streams, the Chelmer and Blackwater rivers, which are subject to great seasonal variation. Storage of several days supply will be provided to avoid using the water at unfavorable times. Treated water is to supplement existing well supply. Dosage used is 1 grain per gallon aluminum sulfate, followed by enough lime water to leave 10 p.p.m. excess CaO. Close regulation of dose is essential and special test using brilliant cresyl blue was devised for colorimetric control. Treated water is recarbonated to prevent development of precipitate and turbidity when mixed with well supply. Final treatment is rapid sand filtration. Excellent bacterial, organic-matter, and color removals are reported. Bacterial and algal after-growth did not occur. No odor was produced. The results of Adams (cf. preceding abstract) on phenol and iodoform tastes are discussed and avoidance of exposure of recently chlorinated water is advised as a means of avoiding tastes due to air-borne phenols from soot and the like. Difficulty with aftergrowths of Bact. coli and Bact. aërogenes in open reservoirs are at times too great to be due to contamination of water by fish, birds, etc. The presence of dead algae is shown to furnish food on which these bacteria thrive. The rôle of oxygen in plumbosolvency is important as the oxide of lead is soluble. The oxide of Cu is less soluble and hence O in water is less important with regard to Cu. Moreover Cu is less toxic than Pb and is not cumulative. Salinity of water modifies solvent action on Pb, but not on Cu. In case of both Pb and Cu any acidity is important, even that due to CO_2, since acids dissolve the oxides. Most im-

portant salts with regard to oxidation of Pb are carbonates and silicates. Carbonates do not prevent oxidation, but react with oxide forming insoluble oxycarbonate. Silicates prevent oxidation of Pb. Pipes of Cu may be used for all except acid waters. Acid waters should pass through Cu pipes only after lining with Sn. The Sn should not be alloyed with Pb as otherwise the Pb will be attacked.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Determining Size of Chimneys. J. G. MINGLE. Power, 63: 9, 332, March 2, 1926. Calculations of draft requirement and method of determining required height and diameter of chimney of minimum cost are shown.—*Aug. G. Nolte.*

Oil as a Boiler Fuel. A. F. BREWER. Power, 63: 9, 349, March 2, 1926. Abstract of paper presented at Midwest Power Conference. To obtain maximum economy from fuel oil used as stationary boiler fuel certain specific facts must be observed. Oil must be properly preheated before firing. Atomization and the ease of pumping are general indications of proper preheating. To insure maximum of heat transfer, furnace and boiler heating surfaces must be clean. Too much excess air, whether intentionally or through leakage in boiler setting, must be avoided. Air required for combustion must be properly controlled. All oil leaks should be stopped, not only to prevent direct waste of oil, but also to eliminate fire hazard. Unwarranted fuel oil specifications should be avoided.—*Aug. G. Nolte.*

Sidelights on Scale and Corrosion. Power, 63: 10, 362, March 9, 1926. Comments on Dr. R. E. HALL's article "Boiler Water Conditioning With Special Reference to High Operating Pressure and Corrosion" delivered before recent Midwest Power Conference in Chicago. Adherent scales that grow in thickness are formed by deposition from the boiler water directly upon the surfaces where they are found. Each layer consists of many crystals the principal axes of which are at right angles to layer. Three substances deposit from boiler water in this manner, namely, calcium sulphate, calcium silicate, and magnesium silicate. Calcium carbonate by itself will not form this kind of scale, but it can become part of scale when loose crystals of it become entangled in matrix of one or more of the three substances mentioned. It can be demonstrated that when two strips of boiler steel are immersed in water containing some electrolyte, such as sodium sulphate, and water touching one strip contains more dissolved oxygen than that touching the other, whole affair will act like a battery if the strips are joined by a copper wire. In this case strip at which oxygen concentration is smaller is the anode, that is, current flows through the solution from that strip to the other, and back through external conductor to first strip. The anode loses weight by corrosion in proportion to amount of current developed. This action has been demonstrated by treating strips of clean boiler steel with distilled water, water containing sodium sulphate only, water containing sodium chloride only, and water containing both sodium sulphate and sodium cloride. Strips treated with above solutions corroded. Addition of sodium hydroxide to the solutions prevented this corrosion. Illustrated.—*Aug. G. Nolte.*

Alternating-Current Motors, Fundamental Principles. B. A. Briggs. Power, **63**: 10, 365, March 9, 1926. Construction of direct current and that of alternating current machines are compared. Such features as slip, pull-out torque, and induction generator are explained.—*Aug. G. Nolte.*

Factors Governing the Purchase or Generation of Power. W. A. Shoudy. Power, **63**: 10, 385, March 9, 1926. Abstract from paper before Philadelphia Engineers' Club, February 16, 1926. When problem becomes one of comparing cost of private with purchased power, following items must be considered: (1) Use factor (and, at times, load factor); (2) Fixed charges, covering interest on investment, depreciation (including amortization, etc.), insurance, rental and taxes; (3) Operating costs, including fuel, repairs, labor and miscellaneous.—*Aug. G. Nolte.*

Stoker-Fired Boiler Unit Develops High Efficiency. Power, **63**: 11, 398, March 16, 1926. Latest boiler unit installed in power plant of Brown and Sharpe Manufacturing Company comprises two Union water-tube boilers each made up of 4-inch tubes 18 feet long, with 3060 square feet of heating surface, set 9 feet 6 inches high under front header. Cross-baffling carefully laid out to maintain approximately constant gas velocity in all three passes. There is no economizer. Boilers set two in battery with division wall between furnaces. Under each boiler is four-retort Riley superstoker equipped with side-wall tuyeres and bridge-wall tuyere plates. Each stoker has projected grate area of 72 square feet. Furnace draft and under-fire air pressure are under automatic control, and steam- and air-flow meters, with a CO_2 recorder, guide operator in adjustment of manual controls. Stoker driven by reciprocating engine; other auxiliaries by alternating-current motors. Tests conducted with great care indicated unusually good efficiency. Overall efficiency was 83 per cent with less than 10 per cent combustible in refuse and with low under-fire air pressure, resulting in power consumption for forced draft fan of less than 0.1 kw.-hr. per thousand pounds of steam generated.—*Aug. G. Nolte.*

Powdered Coal at Ashley Street Station. E. H. Tenney. Power, **63**: 11, 404, March 16, 1926. Furnace changes undertaken to increase boiler capacity and efficiency and eliminate smoke. Relates experiences with eight boilers equipped with unit pulverizers, water-cooled furnace walls, and radiant type superheaters.—*Aug. G. Nolte.*

Hints on the Practical Operation of Air Ejectors. C. E. Colborn. Power, **63**: 11, 410, March 16, 1926.

Estimating Fabricated Pipe Costs. I. A. Butcher. Power, **63**: 11, 414, March 16, 1926. Comparison of costs of gas welded pipe work with a fitting job. Specific examples are given and valuable information imparted to enable an engineer to estimate or check costs for most power plant piping.—*Aug. G. Nolte.*

Operation of Diesel Engines. R. Hildebrand. Power, **61**: 13, 490, March 31, 1925. Notes on engine frames and cylinder liners. Illustrated.—*Aug. G. Nolte.*

Boiler Firing With Natural Gas. R. Tullis. Power, **61**: 13, 494, March 31, 1925. Attendant danger of explosion when lighting burner is pointed out; proper procedure is given.—*Aug. G. Nolte.*

Effects of Impurities in Storage-Battery Electrolyte. G. W. Vinal and G. N. Schramm. Power, **61**: 13, 509, March 31, 1925. Abstract from paper, "Storage Battery Electrolytes," presented at Midwinter Convention of A. I. E. E., New York City, February 9 to 13, 1925. Satisfactory operation of storage battery depends largely upon physical and chemical properties of electrolyte. Experiments in progress at Bureau of Standards to determine quantitatively effect produced by various impurities on rate of sulphation of storage-battery plates. Method involves determination of weight of plates while suspended in solution. Various impurities were added to pure electrolyte, 1.250 specific gravity, and effects produced judged by change in weight of plates. Impurities that affect negative plate only, may be divided into two classes: (a) those deposited quickly in metallic state upon negative plate and producing appreciable gassing; these include platinum, copper and silver; (b) those chemical compounds that are reduced more slowly at the negative plate and result in little, if any, perceptible liberation of hydrogen; these include bismuth, antimony, arsenic and nitrates. Impurities affecting both positive and negative plates include iron, manganese, and chlorine. Impurities affecting positive plate only are organic compounds. Impurities producing little or no effect include sodium, calcium, magnesium, aluminum, zinc, cadmium, and mercury. Specifications for battery acid issued by many different agencies show wide divergence in permissible impurities. A table on the purity of sulphuric acid and solutions for battery use is included in this article.—*Aug. G. Nolte.*

Preventing Breakdowns of Electrical Equipment. C. R. Chace. Power, **61**: 14, 529, April 7, 1925. Divides electrical apparatus failures into four classes and discusses, in considerable detail, proper inspection and maintenance methods.—*Aug. G. Nolte.*

An Obstructed Venturi Meter. R. W. Angus. Power, **61**: 14, 532, April 7, 1925. A 6 inch by 3 inch meter tube obstructed by large piece of wood. Large water bills started investigation. Meter was calibrated with wood in place and correction curve obtained, which enabled a very speedy and amicable adjustment of accounts.—*Aug. G. Nolte.*

Factors Bearing on the Design of Large Turbines. F. Hodgkinson. Power, **61**: 14, 550, April 7, 1925.—*Aug. G. Nolte.*

A New Base Exchanging Silicate for Water Softening. Power, **61**: 14, 551, April 7, 1925. Distinguished from other exchange silicates by its structure.

Called "Doucil." Is a fine cellular body having pores of submicroscopic dimensions. Prepared by complete gelation of a solution made from sodium silicate and sodium aluminate under such conditions of control that its properties are definite and reproducible. According to Mr. Vail, vice-president of American Doucil Company, a cubic foot of the substance contains 25 pounds of anhydrous silicate capable under practical working conditions of absorbing 12,500 grains of calcium carbonate equivalent, i.e., a cubic foot of "Doucil" will soften 1250 gallons of 10-grain water in comparison with 270 gallons of the same water for a like volume of "greensand." Excessive amount of sodium chloride in water suppresses its action. Unsuited to treat waters high in hydrogen sulphide or water containing oil. Entire regenerating operation can be accomplished in 30 minutes.—*Aug. G. Nolte.*

Sea Water Corrosion of Condenser Tube Material. Power, **61**: 15, 567, April 14, 1925. Notes of laboratory tests on action of salt water on copper alloys are given. Many alloys successfully withstood a ten-year attack of sea water. As for copper-zinc alloys with 60 per cent copper and 40 per cent zinc, addition of small amount of tin increases life from two to more than ten years. Alloys unsuitable for condenser tubes are brasses containing more than 85 per cent or less than 70 per cent copper, as well as manganese bronze and aluminum bronzes.—*Aug. G. Nolte.*

Operation of Diesel Engines. R. Hildebrand. Power, **61**: 15, 571, April 14, 1925. Crank-shaft bearings should be kept in alignment by periodic adjustment, to reduce crank-shaft failure. Following are causes of misalignment of shaft: melting away or displacement of babbit due to hot bearing; unequal lubrication; unequal initial pressure in different cylinders; uneven distribution of load on cylinders; non-uniform composition of babbit; and uneven settlement of foundation. Numerous pointers on the inspection of bearings and alignment of crank-shaft are given.—*Aug. G. Nolte.*

Principles of CO_2 Instruments. Power, **61**: 15, 587, April 14, 1925. There are many instruments on the market for automatically determining percentage of carbon dioxide in flue gases; some are indicating only, while others both indicate and record. This article shows by simple diagrams principles upon which most of them operate.—*Aug. G. Nolte.*

Questions and Answers. Franklin Van Winkle. Power. Subjects as follow: **61**: 13, 506, March 31, 1925. Appearance of Burned Boiler Sheet; Latest Cutoff With Single Eccentric Corliss Engine; Engine Clearance; Cracking of Tube Sheets; Warming by Exhaust of Room Air; Wear of Cylinder and Piston; Reducing Proportion of Load on Low-Pressure Cylinder; Stress on Screw Threads of Different-Shaped Pipe Caps; Setting Eccentric of D Slide-Valve Engine; Determining Per cent of Clearance and Cutoff from Indicator Diagram. **61**: 14, 545, April 7, 1925. Use of Boiler Supports for Building Loads; Identifying Dangerous Fire Crack; Larger Safety Valve for Lower Boiler Pressure; Motor Assisting Waterwheel; Steambound Pump; Lap Cracks in Boiler Shells; Cables for Traction Elevators; Combining Diagrams of Com-

pound Engine. **61**: 15, 586, April 14, 1925. Testing Tightness of Boiler Rivet; Six Tons per Twenty-four Hours Equivalent to One Gallon of Water per Minute; Charging Air Chamber When Suction Pressure is Above Pressure of Atmosphere; Setting Valve of Single Valve Engine; Cleaning Water Gauge Glass in Place; Rise of Boiler Pressure from Heat of Setting. **61**: 16, 625, April 21, 1925. Temporary Covering for Back Connection; Head Pressure Pumped Against; Why Pull of Potential Switch Coil is Weak; Importance of Oil Separator on Exhaust-Steam Heating Plant; Power Lost by Shafting Friction; Cutoff Inadmissable for Direct Steam Pump; Bridge Walls and Combustion Chambers for H. R. T. Boilers; Calibration of Pressure Shown by Indicator Diagram; Reading of Meter Dials; Leakage After Removal of Boiler Scale.—*Aug. G. Nolte.*

Iron Bacteria and Water-pipe Incrustation. David Ellis. Surveyor, No. 1757. September 18, 1925. Report upon investigation to ascertain relationship of iron bacteria and other organisms to iron incrustations inside water pipes. Exhaustive examination showed that nodular formation was not caused by presence of iron group, but by imperfect covering of pipes and that iron in nodules was definitely derived from pipes. Stated that while hard incrustations present a physical and chemical problem, and festoon, one that is purely biological, a peculiar ferruginous condition in drinking water is sometimes found, in which both biological and physical factors come into play. In this condition, discoloration has taken place, tint being the familiar yellow of newly formed ferric hydroxide. Iron is present in colloidal form due to exposure of iron to water owing to inadequate protection and presence simultaneously of larger numbers of bacteria than should be found in drinking water. Multiplication of bacteria brings about a change in constitution of water resulting in liberation of carbon dioxide.—*N. J. Howard.*

Report on the working of the King Institute for Preventive Medecine Guindy, Madras, India, 1923–24. J. Cunningham, Director. 1104 samples of water were examined during year, either chemically or bacteriologically. Synopses of reports on individual water supplies are given. Details of outbreak of gastro-enteritis showed epidemic to be caused by bacilli of dysentery group. Experimental filter plant at institute was utilized in testing effect of preliminary filming of slow sand filters with alum. Available results show method to be a promising one for certain types of water.—*N. J. Howard.*

Institution of Water Engineers 30th General Meeting, London, England. Surveyor, 1770, December 18, 1925. **Further Observations on the Biology of Jersey Waterworks.** W. Rushton and P. A. Aubin. Remedial measures for dealing with algal growths should be taken before filtration stage. Little change takes place in water during winter months, active period being February to November. Two periods of excessive diatom growths and one of chlorophyceae occurred. Synedra present over 2000 per cubic centimeter in August. Asterionella present in October to extent of 31,184 per cubic centimeter without production of perceptible taste or odor. Absence of odor presumed to be due to high chlorides (75 p.p.m.). Temperature was not considered as determin-

ing factor for increase in diatoms. Copper sulfate was applied by means of fine spray up to 1 pound per million gallons. Great advantage claimed for spraying over methods commonly employed. When water contained daphnia in considerable quantities, trout fry attained lengths up to 9 inches, as against 4 inches when crustaceae were comparatively scarce. Periodicity of diatoms and chlorophyceae show that in these waters, they follow normal curves for increased numbers. When algae are destroyed, thereby starving the crustaceae, trout fry suffer accordingly. Presence of large numbers of asterionella without giving rise to taste and odor suggests that other factors may exist to cause taste and odor in other waters. Discussion of paper followed in which Sir A. C. Houston, Joseph Race, and Dr. Rushton took part. **An Analysis of Scottish Rainfall Records.** W. N. McLean. Discussion by J. R. Davidson, W. Glasspole, D. Halton, and Thompson. **Recent Studies in Water Purification and Action of Various Waters on Lead and Copper.** J. C. Thresh and J. F. Beale. Details of Sir A. C. Houston's method of excess lime are discussed in relation to certain supplies in England. Factors for purification by excess lime are time and amount of excess lime. In hard water treated, best results were obtained by using one part per 100,000 excess lime and allowing 24 hours for reaction. Total bacterial count was enormously reduced while B. coli was invariably absent in 100 cc. Organic matter was reduced by 50 per cent. Color was reduced to 10 p.p.m. Rapid precipitation and decolorization of water was brought about by using 1 grain per gallon alum applied before addition of lime. It was found to be more economical and efficient to add lime in form of lime water than as milk of lime. In regulating proportion of applied lime water to ensure correct excess of lime, brilliant cresyl blue was used as indicator. Water after treatment was recarbonated with carbonic acid. Quality of water and suitability for treatment were determined by color and turbidity tests. In dealing with chlorination of water, mention made of work of British chemist in showing relationship of atmospheric phenols to odors in treated waters. Rapid sand filtration alone is described as useless in removing B. coli from water; slow sand is vastly better, but not absolutely reliable. Excess lime and chlorine methods can alone be depended upon. Experiments showed that colon bacillus flourished on a weed designated as Enteromorpha intestinalis, which was found growing abundantly in a reservoir and filter beds and led to following conclusion being reached: "that B. coli can grow and multiply prodigiously on the surface of decaying growths, and this is a point of considerable practical importance, since it follows that B. coli found in water do not always indicate manurial pollution. Decaying weeds give rise also to an enormous multiplication of Bacillus aërogenes, a bacillus often confounded with B. coli." Zinc, iron, lead, and copper can slowly take up oxygen dissolved in water. Natural waters containing oxygen in solution slowly oxidize the metal and if oxide formed be soluble in water, it will enter into solution. There is no practical method of removing oxygen from solution in a water supply, but in the case of lead, by addition of silicate of soda effect of oxygen can be prevented, and addition of carbonate will convert any oxide formed into soluble oxy-carbonate which, coating the pipe, seems to prevent further action. In presence of excess of carbonic acid, or any other free acid, lead oxide or oxycarbonate is

dissolved. Copper pipe of a given length and strength is becoming cheaper than lead and is likely to come into general use. Authors think copper pipes of 99.7 per cent purity can be used for all ordinary waters, but if a water contains excess of carbonic acid, or traces of other acid, tinned copper pipe should be used, and the tinning should be guaranteed 99 per cent pure tin. It was found that on some pipe lined with a composition of 50 per cent tin and 50 per cent lead acid waters act nearly as vigorously as upon ordinary lead. Instructive discussion follows by A. E. Cornewall Walker, Sir A. C. Houston, Jos. Race, C. H. Roberts, W. Burgess, and W. Patterson.—*N. J. Howard.*

The Afforestation of Catchment Areas. J. R. Davidson. Surveyor, 1771, December 25, 1925. Necessity is emphasized for reservation of home timber. Position of local authorities as regards afforestation and influence of forests upon climatic conditions and soil erosion are discussed. Failures in afforestation are said to have been caused by lack of skilled advice, organization, efficient labor, and supervision. Discussion of progress already achieved and of future development included.—*N. J. Howard.*

Chlorine in Sewage and Waste Disposal. J. C. Baker. Can. Eng., 50: 2, January, 1926. History and review showing development of chlorination in water and sewage treatment. Chlorine has been used in many forms; calcium hypochlorite, sodium hypochlorite, and gaseous, in aqueous solution, and experimentally as magnesium hypochlorite, as hypochlorous acid, and in combination with nitrogen as nitrogen trichloride and as chloramine. Sewage should not be allowed to become septic before treatment, as this increases amount of chlorine required. Domestic sewage requires between 3 and 20 parts per million; a dose of 5 to 10 parts will usually give a 95 to 99 per cent reduction in bacterial count. In tannery wastes high in organic matter 250 parts are required to kill the spore-bearing anthrax bacillus. Chlorine is being increasingly used for purifying bathing pools. Protection of oyster beds by means of chlorine is receiving increased attention. Theory of action of chlorine in sterilizing water and sewage is discussed. Evidence strongly in favor of view that sterilizing action of chlorine is not due to direct oxidation but to formation of some substance toxic to the organisms. Oxidizing power of chlorine itself can be considerably reduced by combination with ammonium to form either nitrogen trichloride or chloramine, without any loss in its sterilizing capacity and very little alteration of its sterilizing rate, though the compounds, particularly chloramine, have a relatively low oxidizing potential. Chlorine probably acts by attacking the lipoid protein surface of the cellular organisms and forming there some substance which interferes with further cell division, thereby stopping regeneration and resulting in the death of the organisms.—*N. J. Howard.*

Effluents from Ammonia Plants and Their Disposal. J. Lewis Bailey. Surveyor, 68: 1749, July, 1925. Extract of paper read before Institution of British and American Societies of Chemical Engineers. As far back as 1911 Fowler found that phenol was more rapidly oxidized on a bacterial filter than

was thiocyanate. Soil bacteria are capable of decomposing phenol, ortho-, meta-, and para-cresol, and naphthalene. Spent gas liquor, diluted until oxygen consumed in 4 hours is 400 parts per 100,000, is amenable to biological treatment. Experiments were carried out at a gas works, with small bacterial filter, consisting of various sizes of screened clinker impregnated with cow dung and afterwards washed with water. Crude spent liquor containing 178 parts per 100,000 of phenol was passed through the filter and an average of 56 days operation showed phenol reduction of 94 per cent.—*N. J. Howard.*

Removing Dissolved Oxygen From Water. W. J. Risley, Jr. Chem. & Met. Eng., 33: 3, 163, March, 1926. If last trace of oxygen is removed from water no corrosion will take place. Where boiler feed water is first pumped through an economizer, 0.2 cc. of oxygen per liter will cause pitting. Considering both temperature and oxygen content, maximum corrosion is probably at about 150° to 170°F. It is feasible to completely remove all oxygen at temperatures as low as 140°F. by boiling under vacuum. Oxygen may also be removed by passing the water through tank containing large amount of expanded iron.—*John R. Baylis.*

Progress Report of Special Committee on Standard Construction Contracts. Proc. Amer. Soc. Civ. Eng., 52: 3, 225–41, March, 1926. Contains standard contract for engineering construction issued by Joint Conference on Standard Construction Contracts, February, 1925. Following are members of Joint Conference: Am. Association of State Highway Officials, Am. Engineering Council, Am. Institute of Architects, Am. Railway Engineering Association, Am. Society of Civil Engineers, Am. Water Works Association, Associated General Contractors of America, and Western Society of Engineers.—*John R. Baylis.*

Progress Report of the Special Committee on Steel Column Research. Proc. Amer. Soc. Civ. Eng., 52: 3, 146–209, March, 1926. Committee has examined over 600 tests on steel columns. For axially loaded columns of slenderness ratio up to 50 or 60, effect of length is small, and strength of column, if properly designed, is primarily a function of elastic strength of metal. Any formula for calculating strength of columns should give values for short columns closely related to tensile yield point strength of the material, and for long columns, values approaching those given by Euler law. Report gives elaborate discussion of the various details of loading as affecting strength of columns. —*John R. Baylis.*

Progress Report of the Special Committee on Cement. Proc. Amer. Soc. Civ. Eng., 52: 3, 210–22, March, 1926. Committee is studying chemistry of the setting of cement, conditions necessary to bring set about, type and form of compounds in cement which will produce best quality of material after set, effect on resulting set of aggregate and of foreign substances introduced into aggregate, and solubility of cement products.—*John R. Baylis.*

E.N.R. Annual Statistics of Cost and Volume. Eng. News-Rec., 96: 86–7, January 14, 1926. In tabulation of construction contracts—E.N.R. statistics —those for water works during 1925 are shown to number 564, total value

being $69,368,000, compared with 582 in 1924 with total value of $61,445,000. E.N.R. cost volume index numbers are shown graphically for 1924 and 1925, and monthly tabulations are given for period 1914–1915 inclusive.—*R. E. Thompson.*

Concrete Pump Pit Sunk as an Open Caisson. B. Stanley Nelson. Eng. News-Rec., 95: 1078–9, December 31, 1925. Water works system of Vicksburg, Miss., comprises low lift pumps which elevate Mississippi River water into filter basin where it is clarified, and high lift pumps which deliver filtered water from storage into city mains and standpipe. At Vicksburg, Mississippi River has maximum recorded range of elevation from −6.5 to 55, and to enable pumping of raw water at extreme low river stage, pumps must be located in deep pit. Construction of pump pit, which was sunk as open caisson, described and illustrated.—*R. E. Thompson.*

Weight of Stoney Sluice Gates. E. W. Lane. Eng. News-Rec., 95: 1082, December 31, 1925. Diagram given for estimating Stoney gates, based on data reported in literature.—*R. E. Thompson.*

Freezing in Wood-Stave Pipe at Everett, Wash. Eng. News-Rec., 95: 1077, December 31, 1925. About 8 miles of 26½-mile continuous wood-stave pipeline which carries water supply from Sultan River is exposed and each winter some ice collects in exposed portion. Last winter unusually hard frost reduced diameter of line to 8 inches and for few days caused water shortage and resulted in considerable damage to pipe due to breaking off of upper half of stave at ends by expansion of saturated wood on freezing. This damage occurs to lesser extent every winter, even when ice is not formed. Measures employed in overcoming difficulty and in repairing pipe are outlined.—*R. E. Thompson.*

NEW BOOK

Industrial Water Supplies of Ohio. C. W. Foulk. Fourth Series, Bulletin 29, Geological Survey of Ohio, published by The Geological Survey of Ohio, University Grounds, Columbus, Ohio. Price $1.00. The bulletin is divided into three parts: Part I presents general information about water and its behavior in use; Part II presents by chemical analyses the nature of the surface waters of the state; and Part III, the nature of the ground waters of the state. Part I covering 159 pages is presented under 11 main chapter headings as follows: (1) *Origin of the Impurities in Water.* The substances found in water are enumerated, their origin given, and the natural changes taking place are listed. (2) *Meaning of Water Analysis.* It is pointed out that the purpose of almost all water analysis is to answer one of the following questions: (a) Is the water safe to drink? (b) Is it suitable for industrial use? (c) Does it contain substances of medicinal value? The meaning of the results of sanitary and mineral analysis is explained in such a way as to permit the reader to answer these questions readily. (3) *Ways of Stating the Results of a Water Analysis.* Objections to hypothetical combinations are: (a) It is impossible to determine in a solution just how the bases and acids are combined; and (b) There is no

uniformity among chemists as to the methods followed in attempting to combine the bases and acids; all of which results in confusion. The ionic form of statement of analysis is explained together with graphical methods of representing the results. (4) *Calculating Hypothetical Combinations.* The general principles of calculating hypothetical combinations is explained and the methods of the Illinois Water Survey, Bureau of Chemistry, Hale & French are given. Factors are also given by the use of which hypothetical combinations can be computed very rapidly. (5) *Methods of Chemical Analysis.* Methods of analysis given follow closely those outlined in "Standard Methods of Water Analysis, published by the American Public Health Association. The behavior of water is discussed under several headings as follows: in the household; scale formation; corrosion; and foaming. (6) *Interpretation of Industrial Water Analysis.* Stabler's equations for determining in a mathematical form the coefficients of foaming, corrosion and scale formation are given and are much more useable for the water works chemists than as published by Stabler, because an explanation of the philosophy of the plan is given and the meanings of the terms in the equations are explained. (7) *Hardness and Water in the Household.* The behavior of water in the household is discussed principally from the standpoint of hardness and its bad effects. It is estimated that the money saving to each householder due to soft water in Columbus, Ohio, amounts to $23.00 per year. (8) *Scale, Boiler Compounds and Internal Treatment.* Scale, boiler compounds and internal treatment are treated under one chapter; cause of deposition and character of scale are given. The possible good and bad effects obtainable with boiler compounds are listed, and Hall's theory of formation of adherent scale and method of conditioning boiler water are given. (9) *Corrosion.* Nineteen pages are devoted to the subject of sub-aqueous corrosion. The electrolytic and other theories are explained in language that one without chemical training should have no trouble in understanding. (10) *Foaming and Priming.* Professor Foulk points out that contrary to the usual belief, foaming is not caused directly by concentration of sodium salts in the boiler because it has been demonstrated that clean, clear water containing higher concentrations of sodium salts does not foam. He advances a theory according to which soluble salts in the water, by creating a difference in concentration between the surface and the mass of the liquid, make possible the formation of films, which, if caused by the usual inorganic salts, sodium salts, for example, in a boiler water, are not of themselves viscous enough to have a more than momentary existence and therefore never cause serious trouble. But if at the same time finely divided solid matter is present, such as loose scale and sludge, the films will be stabilized and a persistant foam will result. (11) *Purification of Water for Industrial Use.* Under the caption "Purification of Water for Industrial Use," the following methods of purification are described: (a) Lime Soda-ash Method of Softening, Intermittent and Continuous; (b) Miscellaneous Reagents for Softening; (c) Softening by Heating; (d) Zeolites; and (e) Coagulation for Clarification and Decolorization. It is difficult to do this bulletin justice in an abstract because it contains so much valuable information that cannot all be enumerated. Personally, I regard it as the best written and most valuable contribution on industrial water supplies that has yet been published.—*Charles P. Hoover.*